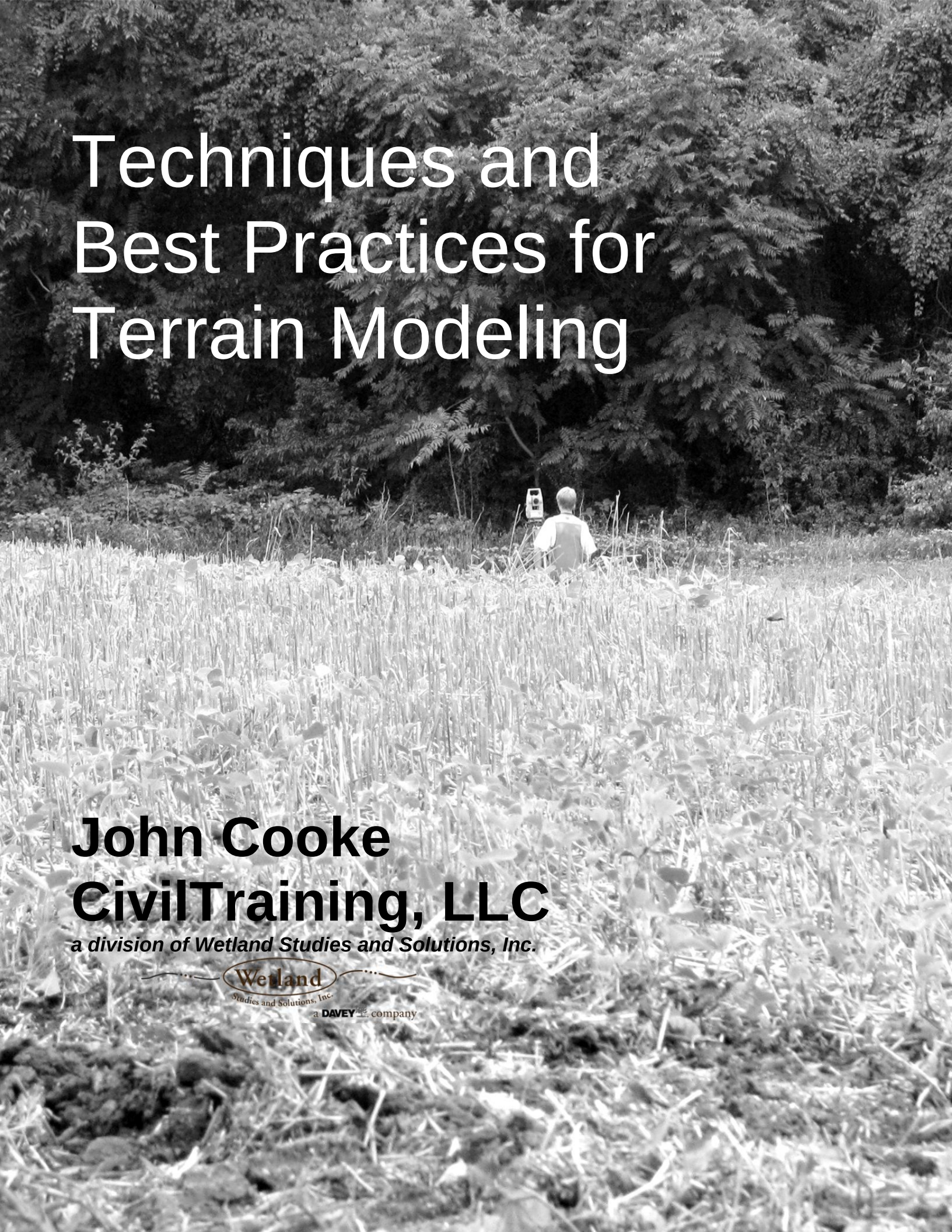

Techniques and Best Practices for Terrain Modeling

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Techniques and Best Practices for Terrain Modeling

Digital Terrain Modeling Concepts

Digital Terrain Modeling is a concept that underlies all calculations in Civil Engineering involving elevation or slope - profiles, cross sections, grading and volume calculations. The process of Digital Terrain Modeling involves the creation of a data structure that the software can instantly "touch" to retrieve elevations or slopes, representing either existing or proposed conditions.

The basic concept behind Digital Terrain Modeling is an old one in the Civil Engineering and Survey industry - interpolation.

Prior to Digital Terrain Modeling, the processing of a network of plotted spot elevations such as those seen in Figure 1.01 involved the interpolation of intermediate elevations between known values as shown. The interpolation lines drawn in Figure 1.01 were conveniently created with the Divide command in AutoCAD®; prior to CAD, this was often accomplished with a graduated rubber band. With the interpolation complete, any intermediate elevation could be obtained, or contours drawn. The process is effective, but time consuming.

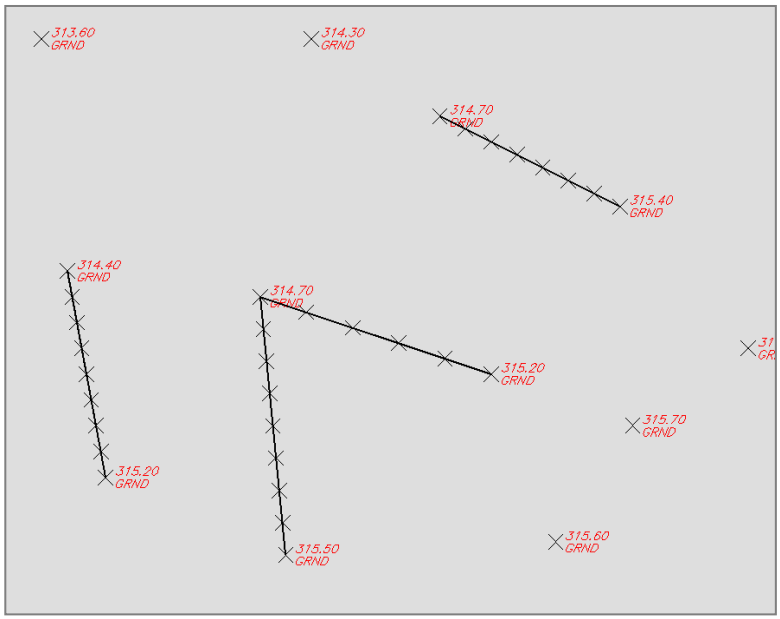

Figure 1.01 - Interpolation Between Known Elevations

Digital Terrain Modeling mathematically completes all interpolation possible between the data supplied, and stores the result in a digital file for easy retrieval. Figure 1.02 shows the triangles that result from Digital Terrain Modeling in Civil 3D®, and the *Tooltip* that results when the cursor is stationary over the digital surface; Civil 3D retrieves the elevation value from the digital surface and displays it in the Tooltip, instantly, and anywhere on the surface.

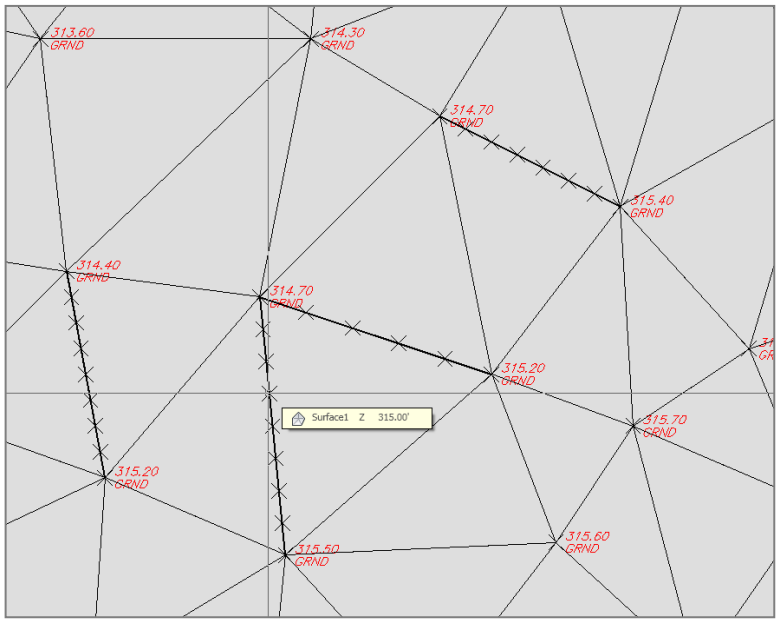

Figure 1.02 - Digital Terrain Model Triangles and Tooltip

The Digital Terrain Models in Civil 3D have the advantage of many display options, through their *Surface Styles*. Displayed as contours, Civil 3D obligingly places a contour in the same location as the interpolated tick.

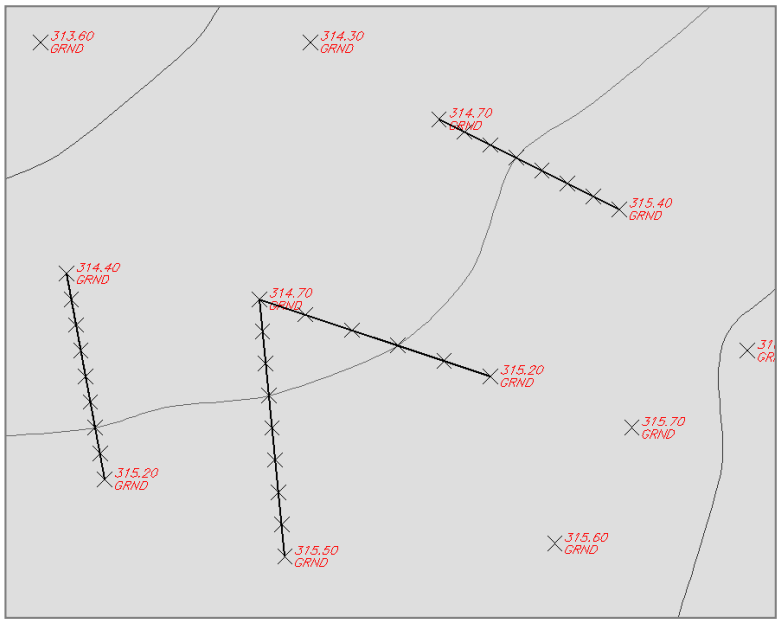

Figure 1.03 - Contours Over Interpolated Ticks

This chapter serves two purposes. The first is to introduce the reader to Digital Terrain Modeling in Civil 3D, a fundamental concept for both existing and proposed as mentioned above. The second objective is to serve as a detailed introduction into the operational aspects of Civil 3D, processing data and building a Civil 3D *Object*. The Civil 3D Surface Object is in many ways the easiest object in the program to grasp and to master, as it is readily created and displayed, and is managed by only a single Style in Civil 3D - a *Surface Style*. As an introduction in this fashion, the examination of surfaces in this chapter is limited to the processing of Aerial or Photogrammetric data. Surfaces can certainly be produced from other data types, including point data, but a discussion of Terrain Modeling from points necessitates familiarity with Civil 3D point management, and is therefore deferred to a later chapter.

Data Types for Digital Terrain Modeling

There are certain data types that are universally applicable to any Digital Terrain Modeling effort in Civil Engineering and Surveying. These data types are constant in any program: Civil 3D, Land Desktop, InRoads, ArcGIS, etc. The three data types which can be used in constructing a DTM are *Point Data*, *Breakline Data*, and *Contour Data*.

- Point Data - Point Data for Digital Terrain Modeling consist of individual discrete X, Y and Z locations, without connecting features between them. Typically these will be spot elevations in a contour drawing, or the mass points themselves in a Mass Points and Breaklines drawing. Critically, the Point Data ***must*** have an elevation or Z component that can be processed in some fashion in building the elevation model. In drawing form, Point Data may be Civil 3D points, AutoCAD points or nodes, or block insertions, text or Mtext inserted into the drawing at true Z elevation. If Point Data are obtained from GIS, they can be used and processed by AutoCAD Map if an elevation attribute is present in the GIS data. Similarly, spot elevation text at elevation 0 in a drawing can be used and processed by Map into an ASCII file, and ASCII files of XYZ format can be used as well.

- Breakline Data - Breaklines are also referred to as Faults, or Features. Breaklines, *as used in this context*, represent the linear edges of site features along which there is a noticeable change in grade. Successfully applied, a breakline forces a deflection in a contour to show a grade change. Examples are edges of pavement, shoulders, toes or tops of slope, toes or tops of wall, water features, etc.

- Contour Data - The definition of contour Data for Digital Terrain Modeling is very specific, and not necessarily what one would expect. Contour Data are strings of point data connected by segments in complex objects; the CAD representation is a polyline. Contour Data do not have to be at constant elevation, as one typically thinks of contours. Contour Data are a fast means of selecting and processing point data, utilizing the vertices of the objects. Most Digital Terrain Modeling applications will also process the segments between the vertices as breakline data, and can filter out vertices too close together or add interpolated vertices if required. Contour Data must be at a correct Z elevation to be processed in a Terrain Model. Polylines must be at a correct Z, either constant as a 2D polyline, or varying, as a 3D polyline. GIS data can again be used, and AutoCAD Map can read elevation attributes from GIS Contour Data and apply them to polylines through a Property Alteration Query.

Most Civil Engineering and Surveying applications will utilize some combination of data types in a Terrain Model; having two types present is common and all three is not unusual at all.

Critical Civil 3D Surface Feature Settings

Civil 3D has the advantage of being an infinitely customizable program. This advantage allows Civil 3D to be used effectively in almost any locale or units. Civil 3D has the disadvantage of being an infinitely customizable program. This disadvantage means that there are a plethora of Civil 3D settings that control the program, and a concurrent risk that an important setting could be overlooked.

Every element, or ***Feature***, in Civil 3D has its own settings. This means that there are settings that control the creation, interaction and editing of surfaces, as well as points, alignments, parcels and every other portion of the Civil 3D system. Civil 3D ***Feature Settings*** determine the default styles that will be applied to each feature, various options unique to the feature's operation, and then ***Feature Command settings that fine-tune the way Civil 3D operates***.

Feature Settings are among the options controlled on the Toolspace's *Settings* tab, and are exposed under each of the various collections listed there. Many Feature Settings can be set at the time data are actually created, rather than prior to use. Some Feature Settings can be adjusted "on the fly", such as those for Point Creation. Civil 3D Surface Feature Settings are exceptional, in that ***certain critical Surface Feature Settings must be made before any surfaces are created in Civil 3D***.

To begin examining Surface Feature settings, expand the **SURFACE** collection on the **TOOLSPACE'S SETTINGS** tab. Also expand the **COMMANDS** collection below Surfaces.

Civil 3D Feature Settings are always found at two levels on the *Settings* tab: at the parent level of the collection (*Surfaces* in this case), and at the appropriate command level for the Civil 3D command to be used (*CreateSurface*, which we'll get to shortly).

To examine the settings at the Surfaces parent level, **RIGHT-CLICK** on **SURFACES** and pick **EDIT FEATURE SETTINGS** from the menu.

In the *Edit Feature Settings - Surface* dialog two different glyphs can be seen.

Settings with the glyph are actually inherited from the general Civil 3D *Drawing Settings* made earlier. Any changes made to these settings will affect Surface settings only; settings for any other feature in Civil 3D will continue to reflect the global drawing settings. An edit of this type would also result in a Child Override indication in Drawing Settings as discussed in Chapter 1011.

Settings with the drunken pentagon glyph - - are the settings unique to and introduced by the actual Surfaces level.

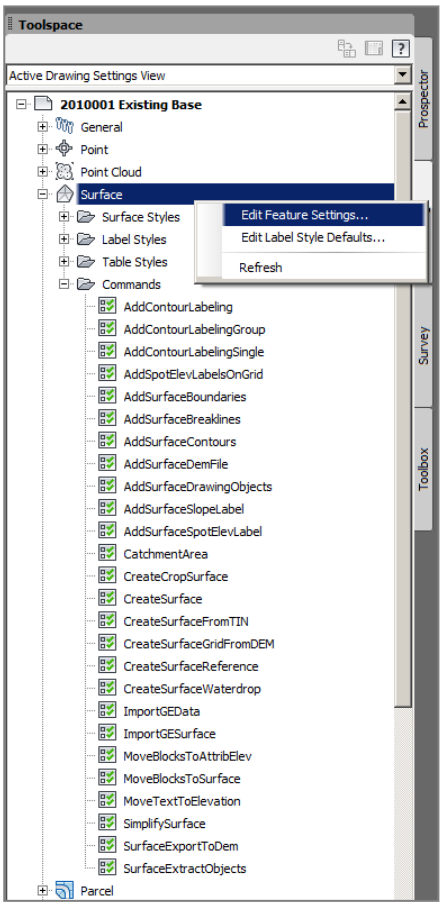

Figure 1.23 - Surface Collection and Command Settings on Settings Tab

Of the three Surface Settings levels in the dialog, only one is really important at all before creating a surface, the **SURFACE DEFAULT STYLE**. Set to Border Only in this template, the surface will initially display only as its perimeter or border when built, and this setting can easily be overridden when the surface is built. There is clearly nothing critical here, so press **OK** to close the parent surface Feature Settings.

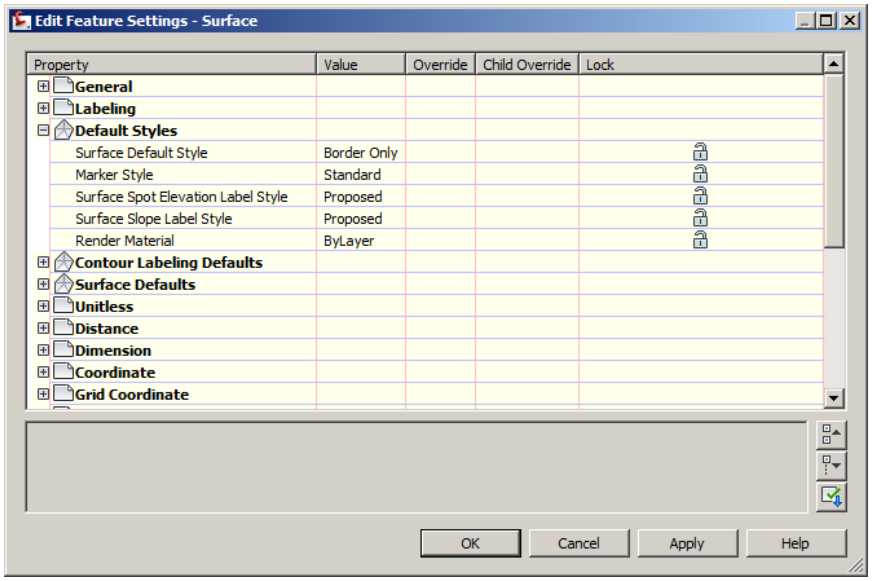

Figure 1.24 - Edit Feature Settings - Surface Dialog

The second level of Civil 3D Feature Settings that should always be checked on the *Settings* tab is at the appropriate command level for the Civil 3D command to be used. In this instance we are about to create a surface; to access the setting for this operation **RIGHT-CLICK** on **CREATESURFACE** under **COMMANDS**, and pick **EDIT COMMAND SETTINGS** from the menu.

Again, different glyphs can be seen in the *Edit Command Settings - CreateSurface* dialog. The and glyphs again refer to settings inherited from the collections above, Drawing Settings and Parent Surface Feature Settings respectively. Changes made at these levels in this dialog would again be child overrides having no effect on the drawing or feature settings above.

The new glyph pertains specifically to the operation of creating a surface, and there are two levels: **SURFACE CREATION** and **BUILD OPTIONS**.

Opening the first collection, **SURFACE CREATION,** the options look pretty straight forward. One option that is somewhat new is the ability to select the **SURFACE DEFAULT TYPE**. Civil 3D can build not only *TIN Surfaces* but *Grid Surfaces*. TIN's are Triangulated Irregular networks, a specific type of terrain model common to Land Desktop and many other Civil Engineering and Surveying applications. TIN's are preferable for profiles and cross sections based on the accuracy of their triangle-based model, but they are not necessarily visually pleasing. Grid surfaces, the other type that can be produced by Civil 3D, model a surface using quadrangles.

Grid models tend to be visually smoother, but less accurate for engineering purposes. Most surfaces built in Civil 3D will be TIN's so this doesn't seem that important either. The operator is being lulled into a false sense of security at this point, but a huge land mine in Civil 3D is looming....

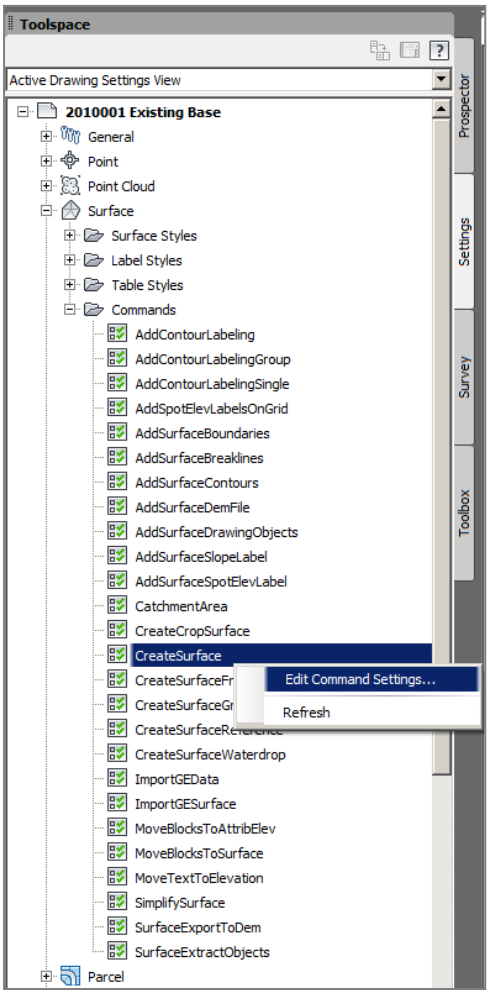

Figure 1.25 - Surface Command Settings on Settings Tab

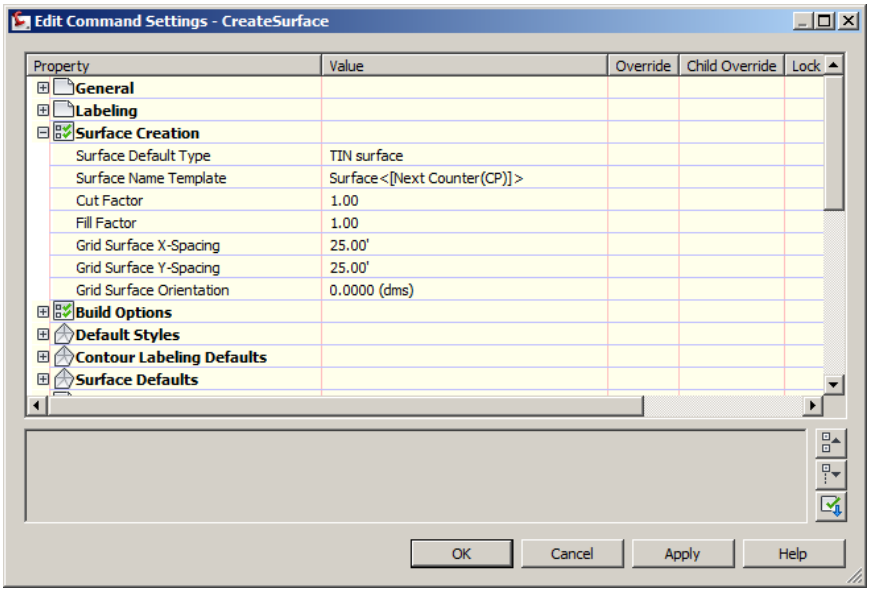

Figure 1.26 - Edit Command Settings - CreateSurface - Surface Creation

Collapsing the **SURFACE CREATION** collection and expanding the **BUILD OPTIONS** collection, things still appear reasonably familiar. Here the program can exclude data below or above a threshold value, familiar to anyone who has used Land Desktop. There are other data filters, actually restored from earlier versions of Softdesk. One setting seems to stand out though; **ALLOW CROSSING BREAKLINES**. Set to **YES** in this template, the out-of-the-box setting for this value as supplied from Autodesk is **NO**.

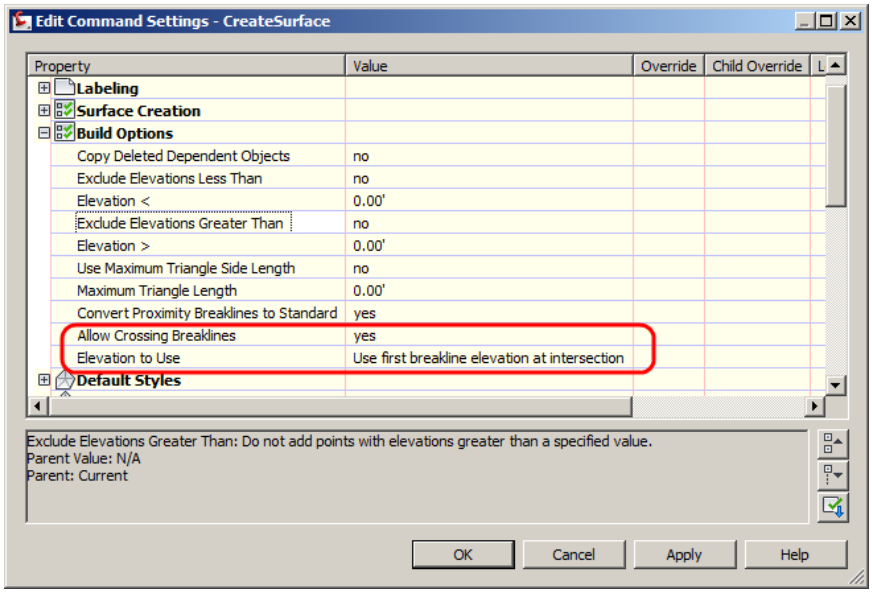

Figure 1.27 - Edit Command Settings - CreateSurface - Build Options

Anyone who has used any previous Civil product knows that a basic tenet of terrain modeling is that Breaklines, *as already defined in this chapter*, cannot cross. In Land Desktop, when one breakline crossed over another one or both would be ignored. This rule extends even to field work - surveyors are taught that when running linework for bottom face and top face of a curb, in a curve, care must be taken to align the bottom and top shots together so the fault lines will not cross. It has always been that way. So why does this setting seem to negate a basic rule of terrain modeling, and allow crossing breaklines? And who would want to anyway?

The answer is simple: **Autodesk is changing the rules - and the language - on the fly**. ***Used in this dialog, Breaklines, does not mean Breaklines*** as we have defined (and used for years). ***Breaklines means TIN Triangles.*** The setting means "***Allow Crossing TIN Triangles: Yes, or No?***"

As confusing as this seems, one must know a little more about how TIN's are constructed in Civil 3D before answering the question. Unlike Land Desktop, Civil 3D does not wait until all data are selected for the surface then perform the interpolation between all selected data. Civil 3D builds the surface interactively as each set of data are added...

As already described, many surfaces are built from a combination of data types. In this example, the aerial spot elevations will be used, the contours will be used, and (true) breaklines will be developed and used. Building the TIN in Civil 3D, ***as soon as the spot elevations are selected the program will build TIN triangles between them***. The contour vertices will then be added to the TIN in a second step. If the "***Allow Crossing TIN Triangles: Yes, or No?***" setting is set to ***No*** (the factory default), ***Civil 3D will cheerfully reject the addition of the contours to the surface***. The obscure "***Allow Crossing Breaklines***" setting will reject them. This operation results in an unexpected occurrence of the Event Viewer, packed with warning messages, frustration, and calls to tech support.

In order to build a surface from more than one type of data in Civil 3D the "***Allow Crossing Breaklines***" must be set to ***Yes***.

The Allow Crossing Breaklines setting must be set to Yes in Civil 3D.

Now that the "***Allow Crossing TIN Triangles***" land mine has been avoided, a second one appears. Setting the **Allow Crossing Breaklines** option to **Yes** enables another setting below it, **Elevation to Use**. This option has three choices, one of which uses the dreaded "A" word. This setting determines how triangle edge elevations should be handled when triangles already built are reevaluated by the addition of another set of data: *Should the elevation of the first data set be used, the elevation of the last data set be used, or the elevations averaged (argh).*

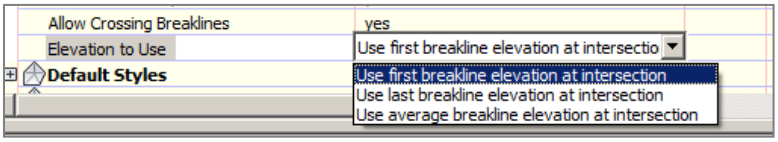

Figure 1.27 - Determination of Elevation to Use for crossing TIN Triangles

Again, some deeper analysis is required. Consider for a moment a cross sectional topographic survey of a road, and the production of a TIN from the data. The field crews set stationing, and shoot cross sections at a defined interval, for sake of example 25 feet. The road in question involves a crown, edges of pavement, and edges of shoulder. The crew runs linework for the crown, EP's and shoulders, and these lines will be used as breaklines in the surface.

Additionally, the crew also picks up other points on the road surface: manholes, inlets, water shutoffs, gas shutoffs, traffic light trip plates and the like. All of these data will be added to the TIN as points.

The most reliable way to build this TIN is to set the **Elevation to Use** setting to **Use first breakline elevation at intersection**, then to ***select the breaklines for the surface first***, ***then select the point group***. ***This allows the TIN to be built first from the breaklines, which properly model the general cross sectional characteristics of the crowned road. Adding the points second then allows the TIN to deflect up or down in the areas influenced by individual points within the general shape of the road. If the point data were selected first when building the surface the TIN would connect the manholes, inlets, water shutoffs, gas shutoffs, and traffic light trip plates, forming triangles whose elevations would not be changed by the later addition of the breaklines.***

The way to use the Terrain Modeler in Civil 3D is to set the **Elevation to Use** setting to **Use first breakline elevation at intersection**, then to ***select data for the TIN based on its accuracy, adding the most accurate data first, and moving sequentially through data of lesser accuracy.***

This concept is critical for successful use of the Terrain Modeling in Civil 3D! Civil 3D arguably has the best Terrain Modeler that has ever appeared in an Autodesk product. It has many new settings and concepts, and, once understood, can produce TIN's of exceptionally high quality.

The Elevation to Use setting should be set to Use first breakline elevation at intersection, and then data should be selected for addition to the TIN based on their accuracy, with higher accuracy data selected first.

Set the **Allow Crossing Breaklines** and **Elevation to Use** settings as described, and press **OK** from Command Settings.

Starting the Surface in Civil 3D

To begin creating the existing aerial surface in Civil 3D, change to the **PROSPECTOR** tab. **RIGHT-CLICK** on the **SURFACES** collection, and click **CREATE SURFACE** from the menu.

It should be noted that this is only one of several methods to start the surface. The process can also be started from the Home tab of the Civil 3D Ribbon, Create Ground Data Panel, Surfaces Dropdown, Create Surface. The interface used is the preference of the operator. In many instances right-clicks from the Prospector will be used in these chapters; we feel these are faster in many cases, and are available to readers using versions prior to Civil 3D 2010.

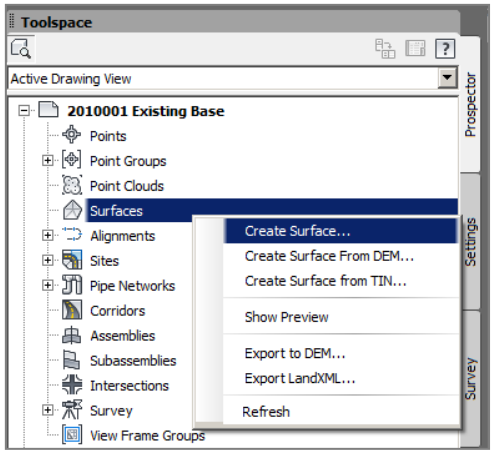

Figure 1.29 - Create Surface in Prospector

The *Create Surface* dialog appears. Taking care of the easy entries first, supply the surface **NAME** and **DESCRIPTION**.

A less-than-obvious consideration for the surface name is the capitalization. Since the surface name will be suffixed to a layer name, be sure to type the surface name in all caps if your layer naming convention is to use capitals.

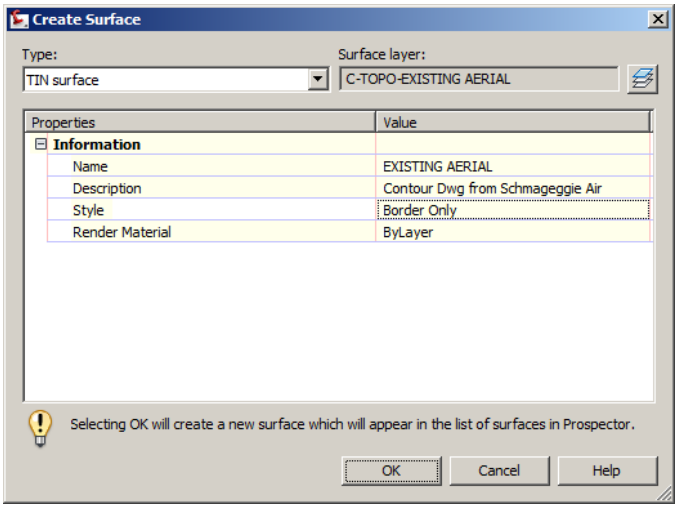

Figure 1.30 - Create Surface Dialog with Name and Description

The **SURFACE LAYER** in the upper right corner of the dialog is wrong for an existing surface; a *C-TOPO* surface would be for proposed. Since this surface is from aerial data the base layer needs to be changed to R-*TOPO*. To override the layer press the button in the upper right. As the *Object Layer* dialog opens press the button in its upper right. **SELECT** a new base layer, or use the **NEW** button to create a new base layer. Press **OK** from two dialogs back to *Create Surface*.

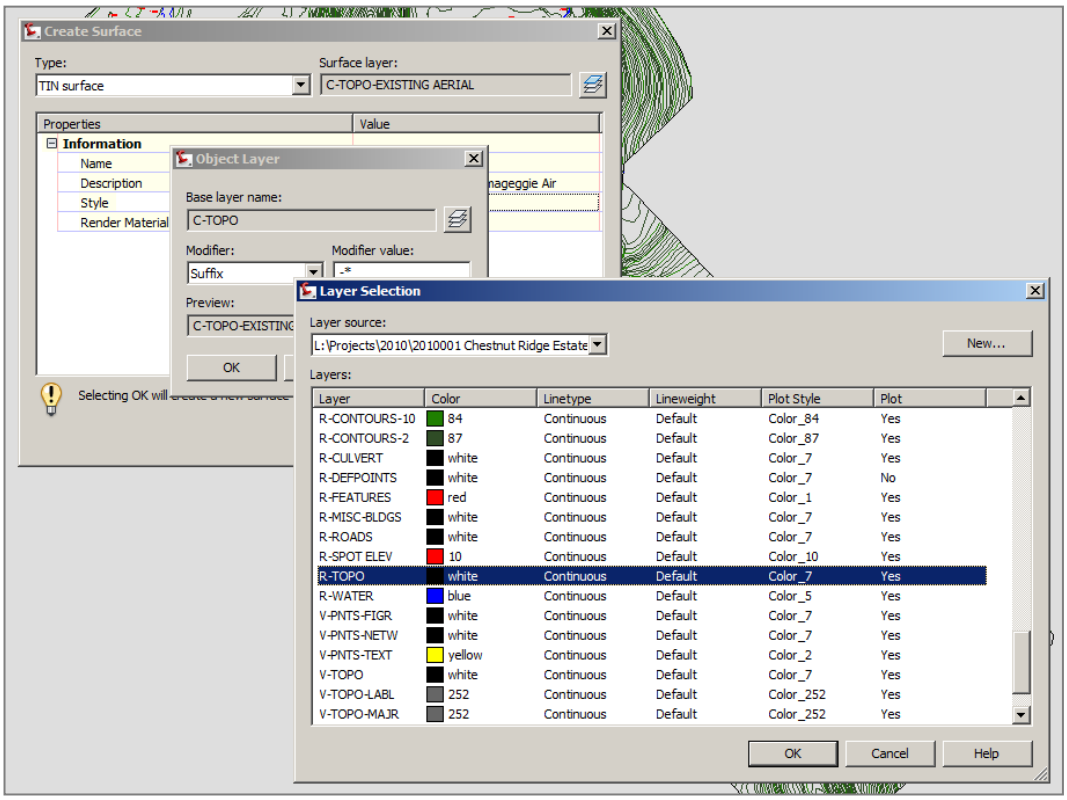

Figure 1.31 - Dialogs to Change Surface Base Layer

The Border Only style set as the default for surface creation will not give a good sense of how the TIN is built in Civil 3D. Change it by clicking on the button in the **STYLE** field. As the *Select Surface Style* dialog opens, use the drop arrow to select Triangles Only as the new surface style. Press **OK** back to the *Surface Creation* dialog, and press **OK** from there.

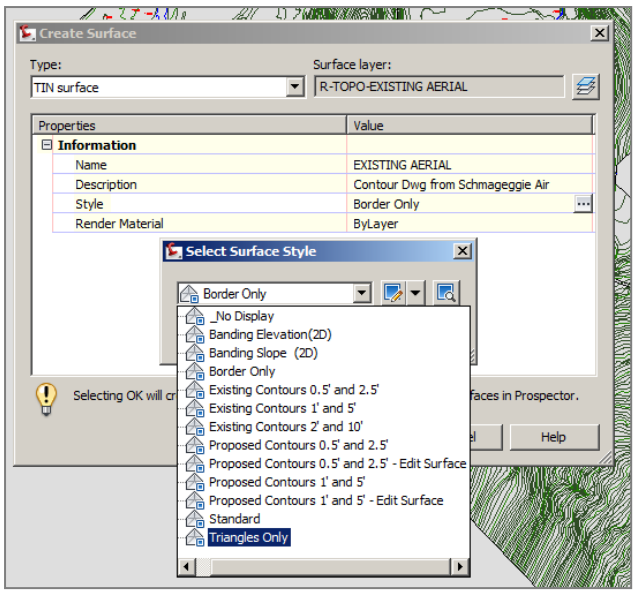

Figure 1.32 - Selection of Surface Style

The new empty EXISTING AERIAL surface definition is added to the Prospector. Use the ⊞ glyphs to expand the levels below it, including the *Definition* level where data will be added.

If the Prospector can be thought of as the equivalent of the Land Desktop Terrain Model Explorer, it must also be thought of as the equivalent of the Land Desktop TIN data file. The TIN in Civil 3D exists only in the Prospector in this drawing, not in an external data file, unless it must be exceptionally large.

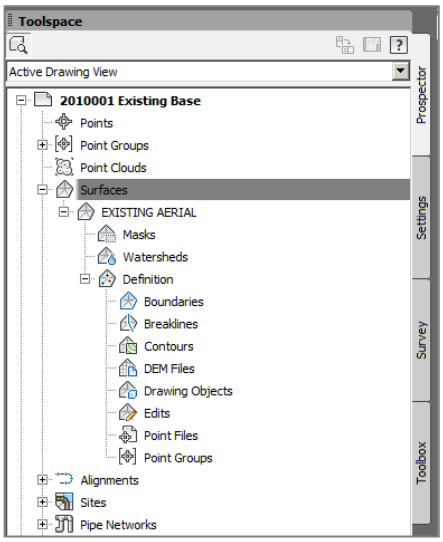

Figure 1.33 - Surface in Prospector

Adding Spot Elevation Data

The surface in the example project will be built from a combination of spot elevation, breakline and contour data; following the advice given above the breakline data would normally be added to the surface first, as these data are of the greatest accuracy or significance. For instructional purposes we will deviate from those instructions here in the interest of showing exactly how a surface is built by Civil 3D, and will add the spot elevation data first. In normal practice, the spot elevations would be the last data added, after the breaklines and contours.

Data should be selected for addition to the surface based on their accuracy, with higher accuracy data selected first.

In order to facilitate some layer management magic that will be needed to select the spot elevations it is helpful if their layer is made current; if there is more than one layer of spot elevation data to be used, any one of them can be made current.

Remembering that the spot elevations in this drawing are AutoCAD points, they will be added to the surface as *Drawing Objects*. **RIGHT-CLICK** on **DRAWING OBJECTS** under the **DEFINITION** level for the EXISTING AERIAL surface, and pick **ADD** from the menu.

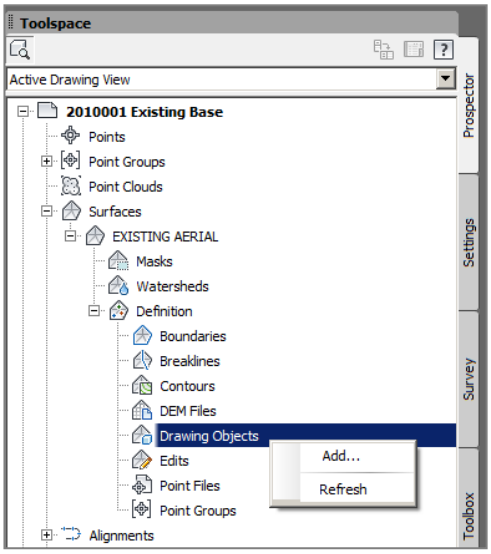

Figure 1.34 - Add Drawing Objects from Prospector

The *Add Points from Drawing Objects* dialog allows selection of a variety of AutoCAD entities; select **POINTS** from the list, corresponding to the objects found in the drawing. Supply a **DESCRIPTION** for the objects, and press **OK** to select them in the drawing.

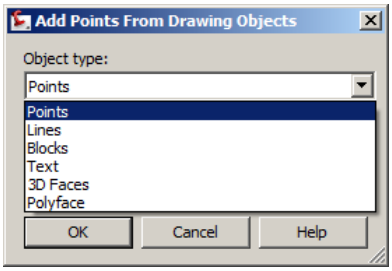

Figure 1.35 - Add Points from Drawing Objects

The `Select objects:` prompt appears, requiring the selection of the spot elevations in the drawing. This is one of the places where Civil 3D differs substantially from Land Desktop: *selection by layer is not an option*. Civil 3D lacks the social graces that Land Desktop had in many areas; rather than offering a custom selection option, Civil 3D usually reverts to regular AutoCAD selections. It would have been possible to *isolate* the spot elevation layer before starting the selection, and that would have worked fine. The disadvantage to isolating the spot elevation layer, from a training standpoint, is that the surface layer would be turned *off* by that operation and the surface not displayed until the isolate reversed (assuming, of course, that isolate is set to turn layers off....). The best solution to selecting data for the surface is to revert to an old AutoCAD trick - a ***transparent command***.

At the `Select objects:` prompt type **'LA** and press **ENTER**; the *Layer Properties Manager* appears inside, and without interrupting, the AutoCAD selection! In the *Layer Properties Manager,* turn off all layers except the spot elevations - R-SPOT ELEVATION in this case. Press **OK** to exit the *Layer Properties Manager,* returning to the `Select objects:` prompt.

SELECT all of the spot elevations with a **WINDOW** or **CROSSING** selection, ***but do not hit Enter to close the selection***.

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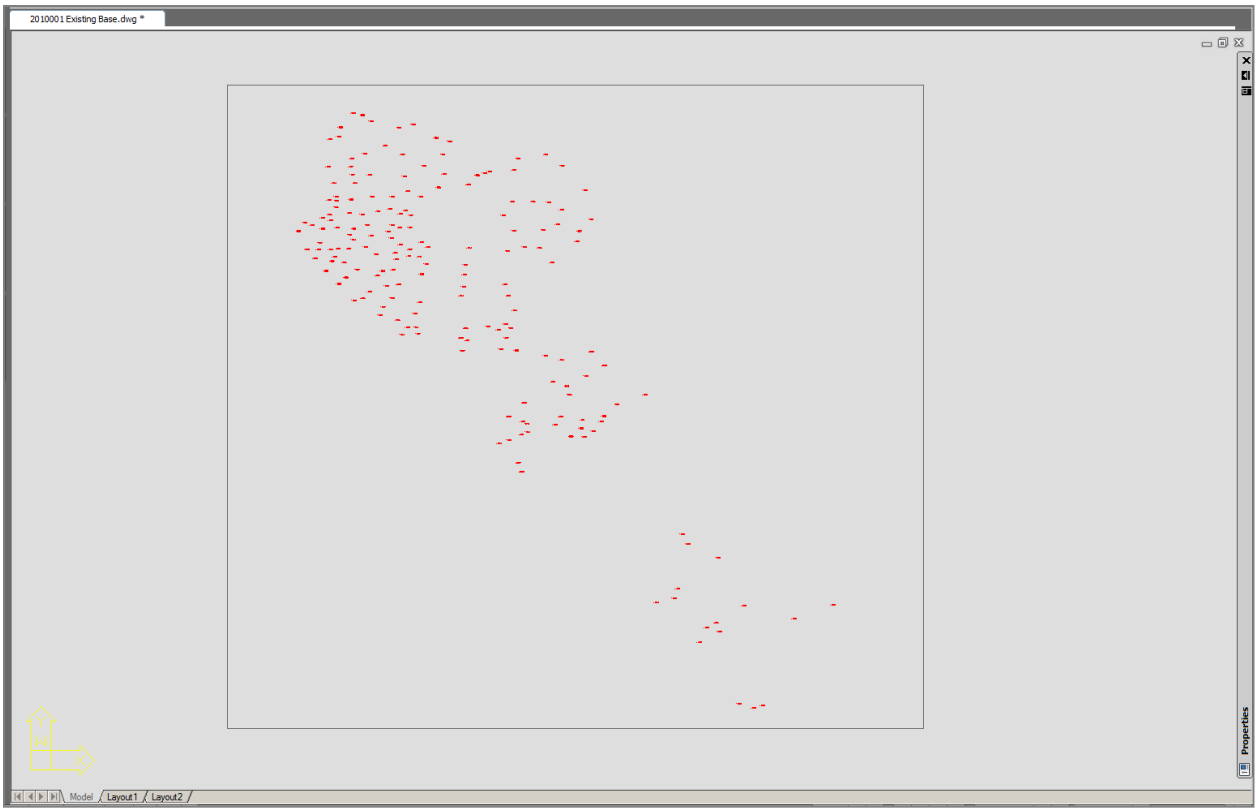

Figure 1.36 - Selecting Spot Elevations with Crossing

AutoCAD is still at the `Select objects:` prompt; again type **'LA** and press **ENTER** to redisplay the *Layer Properties Manager*. Turn the layers back on (or restore a layer snapshot to be really tricky), and again press **OK** to exit the *Layer Properties Manager* and return to the `Select objects:` prompt.

At this point, the selection and layer hocus-pocus are done; press **ENTER** to end the selection, and Civil 3D builds the surface.

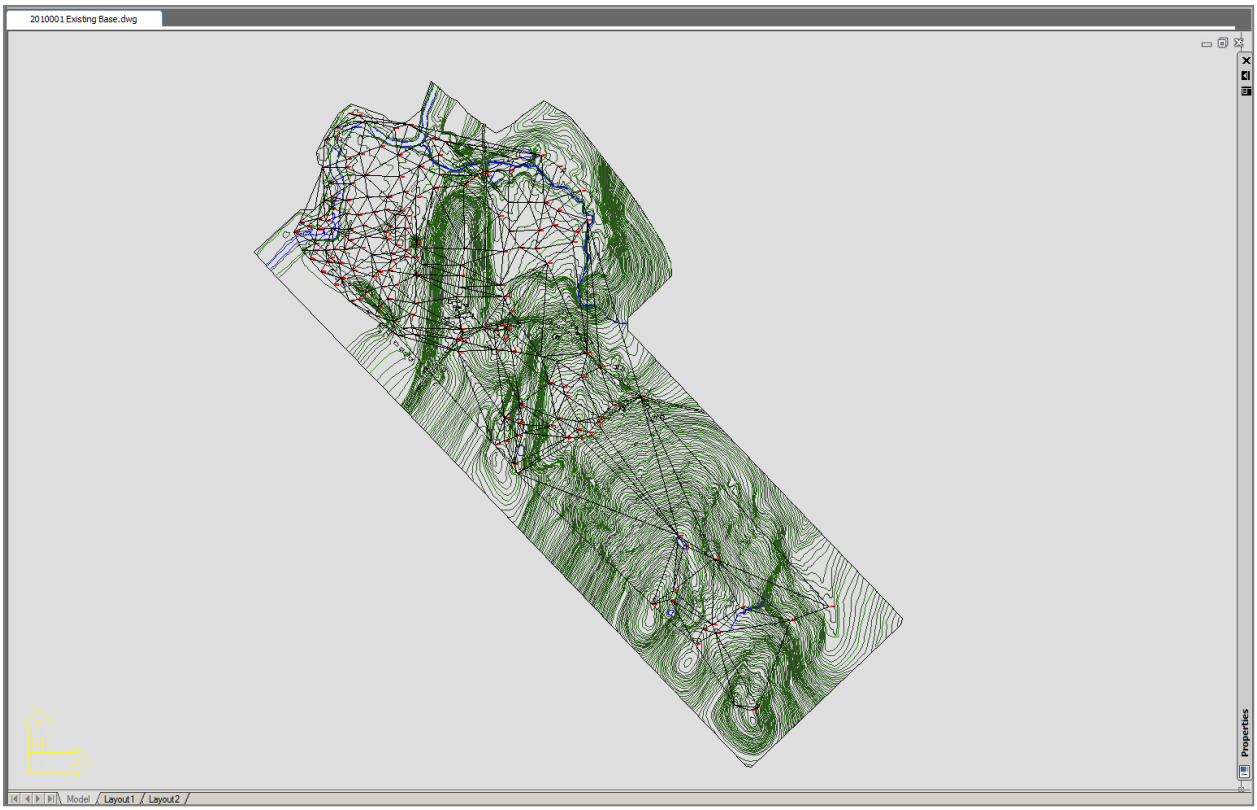

Figure 1.37 - Drawing with Surface from Spot Elevations

A lot just happened; let's look at the transparent layer stuff first. Many AutoCAD commands can be run *inside* another command by typing their command name prefaced with an apostrophe as we did here. This is an extremely old AutoCAD trick, and has been around at least since AutoCAD 10. Autodesk used to allow this by picking many of the icons in earlier versions; it was possible in earlier releases to trigger the Layer Properties Manager transparently by picking its icon from the Layers toolbar, but it doesn't work in 2010. Typing still works though, and typed commands will often allow access to parts of AutoCAD that just can't be reached any other way. While we're on the topic, other niceties like *layer previous*, *layer isolate*, ***don't*** work transparently, whether typed or picked - only the low level AutoCAD commands work.

There also wasn't a better way to do that selection set inside the Civil 3D command. *Select similar* doesn't work there, nor does a *PICKFIRST* selection work. You can pass a selection set to the command with ***P*** for previous, old school AutoCAD again.

Now let's turn our attention to the surface built in the drawing. As soon as data are selected for a surface in Civil 3D the surface is built, totally different from the process in Land Desktop. The surface has triangulated between the spot elevations selected, and the Triangulated Irregular Network, or ***TIN***, shows in the drawing. The TIN is displayed in the drawing based on our selection of a Surface Style that shows it, Triangles Only; more on the Surface Style later.

Clicking on a TIN line in the drawing it is obvious that the whole TIN is one object in the drawing; the *Properties Palette* lists it as a ***TIN Surface***, and venturing into the *List* command reports it as a ***AECC_TIN_SURFACE***. It is important to remember that the surface in Civil 3D exists only in the drawing. There is no database. The information shown in the Prospector is the data structure itself. Clicking on the **DEFINITION** level in the Prospector shows a summary of the data currently in the surface in the

pane at the bottom. If the TIN is erased from the drawing, it is gone. Period. It's also gone if Joe Autocad explodes it, but that's another topic....

At this point it's advisable to save the surface. Since it's drawing data, **SAVE** the drawing.

Adding Contour Data

Contour data will be the next information added to the surface. Since some layer management magic is coming once again, set one of the contour layers current.

Remember that the contours in this drawing are polylines, and that they have a significant number of vertices. They will be subject to filtering when selected, a process known as *contour weeding*.

Selection of contour data begins in the Prospector again, **RIGHT-CLICKING** on **CONTOURS** under the **DEFINITION** level for the EXISTING AERIAL surface, and picking **ADD** from the menu.

What pops up next is the *Add Contour Data* dialog, with contour ***Weeding factors***, ***Supplementing factors*** and ***Minimize flat areas*** settings. This is one of the most misunderstood dialogs in Civil 3D, but a critical dialog from the standpoint of TIN accuracy, so some detailed explanation is in order.

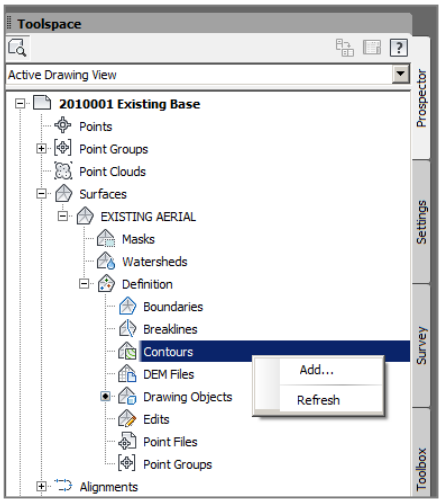

Figure 1.38 - Add Contours from Prospector

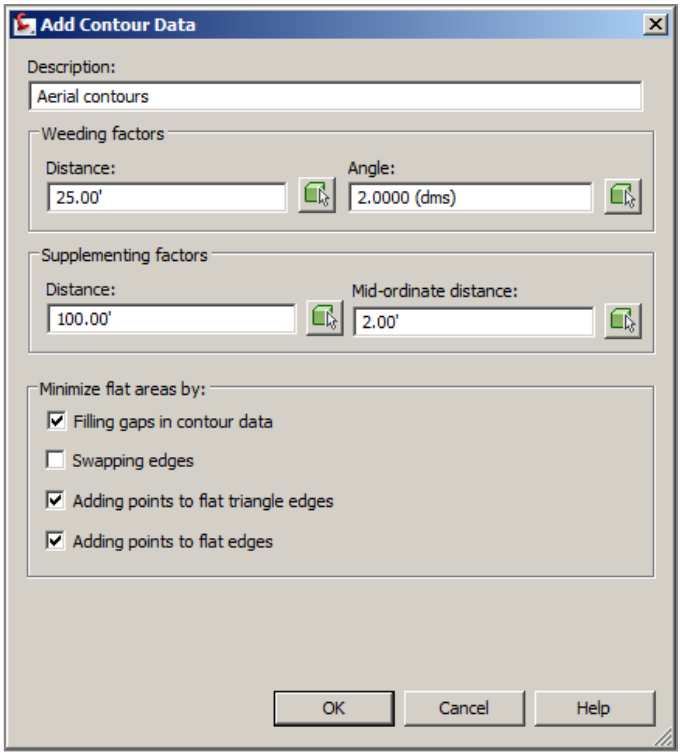

Figure 1.39 - Add Contour Data Dialog

Weeding Factors

The ***Weeding Factors*** in the *Add Contour Data* dialog supply the filtering of vertices on contours selected for inclusion in the TIN. Remember that each contour vertex added to the TIN becomes the endpoint of a TIN triangle; if there's too many vertices you'll need to lease time on a Cray to build the TIN. The Weeding Factors filter out vertices too close together through the application of a Weeding Distance and Weeding Angle, which are applied *together* to filter along each contour.

The first three vertices of a contour are shown in Figure 1.40.

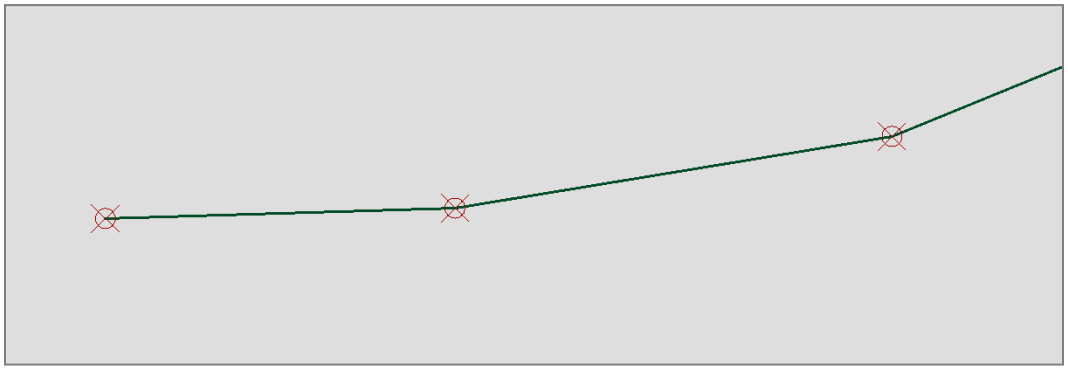

Figure 1.40 - Vertices Along Contour

The Weeding process begins by examining the Distance through the first three vertices of the contour as highlighted in red in Figure 1.41. If this cumulative distance through the first three vertices is ***greater than or equal to the Weeding Distance specified in the Add Contour Data dialog the vertex will be used*** in the TIN, and the program continues, evaluating the next three vertices in the contour. If this cumulative distance is ***less than the Weeding Distance specified in the Add Contour Data dialog the program evaluates the Deflection Angle between the vertices***.

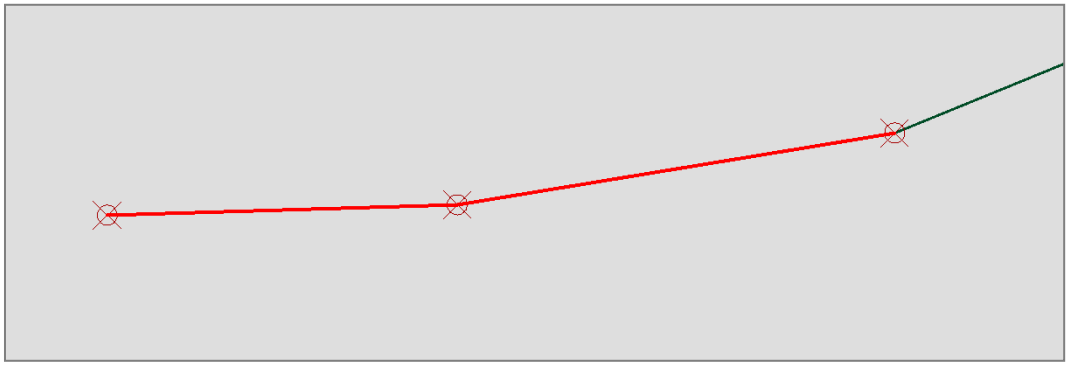

Figure 1.41 - Cumulative Distance through Three Vertices

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The Deflection Angle is evaluated as shown in Figure 1.42. If the Deflection Angle is ***greater than or equal to the Weeding Angle specified in the Add Contour Data dialog the vertex will be used*** in the TIN, and the program continues, evaluating the next three vertices in the contour.

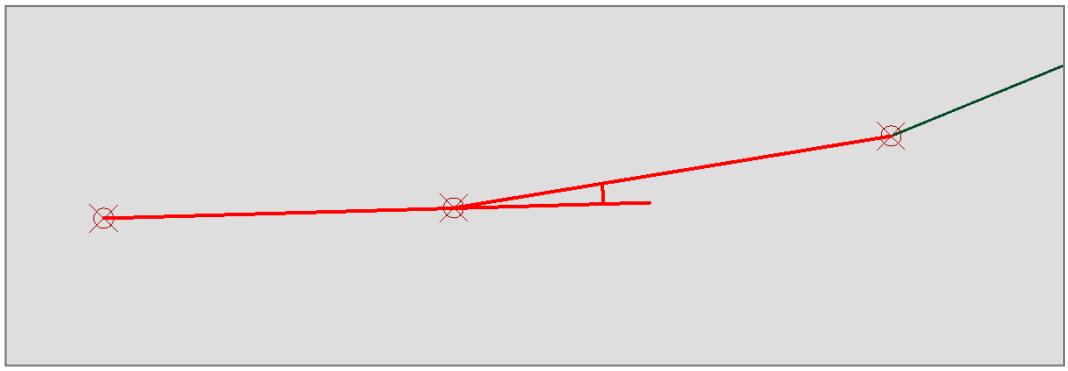

Figure 1.42 - Deflection Angle through Three Vertices

If, however, the Deflection Angle is also ***less than the value specified in the Add Contour Data dialog the contour segment is too short, too straight, and the intermediate vertex will be ignored in producing the TIN,*** much as shown in Figure 1.43. The program continues to evaluate the next combination of three vertices along the contour, and cycles through all contours selected.

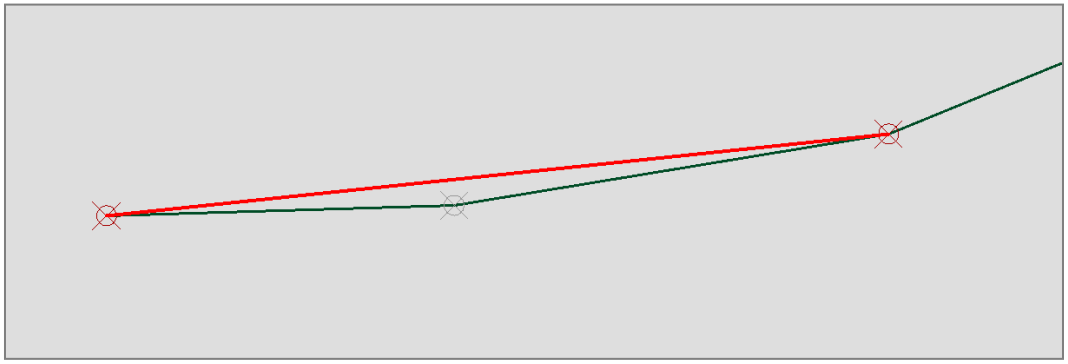

Figure 1.43 - Resulting Treatment of Short, Straight Segment

It should be noted that Contour Weeding in building a surface does not remove vertices from the contours; it simply filters which vertices will or will not be used in the surface.

The challenge in working with Civil 3D is to come up with numbers for contour weeding to plug into the dialog box. For sites ranging in size from 10 to 250 acres a good rule of thumb is 25' of weeding distance and 2° of angle. The numbers can be decreased for smaller sites and increased for larger ones.

With the objective of the *Weeding Factors* being to remove vertices too close together along a contour, the objective of ***Supplementing Factors*** is to add vertices to polylines having very few. Supplementing is especially important with filleted contour polylines such as are seen in proposed surfaces, as a filleted polyline has no vertices around the arc.

Supplementing Factors

Supplementing consists also of two values, but they are applied *separately* rather than together. The ***Supplementing Distance*** is applied through *straight* segments of a contour, between vertices, and the ***Mid-Ordinate Distance*** is applied through a true *arc*.

A portion of a filleted contour is shown in Figure 1.44. The original segment is shown in green, and it has four vertices: the endpoints and beginning and end of the arc. Without supplementing these would be the only vertices used in the TIN, and it would jump right across the arc.

The ***Supplementing Distance*** is applied to the contour first as shown in Figure 1.44. The program measures down the contour by the ***Supplementing Distance;*** if a vertex is not found one is added. This process continues to, and resets at, the next actual vertex, and skips over the arc as seen, continuing to add more vertices with the same spacing.

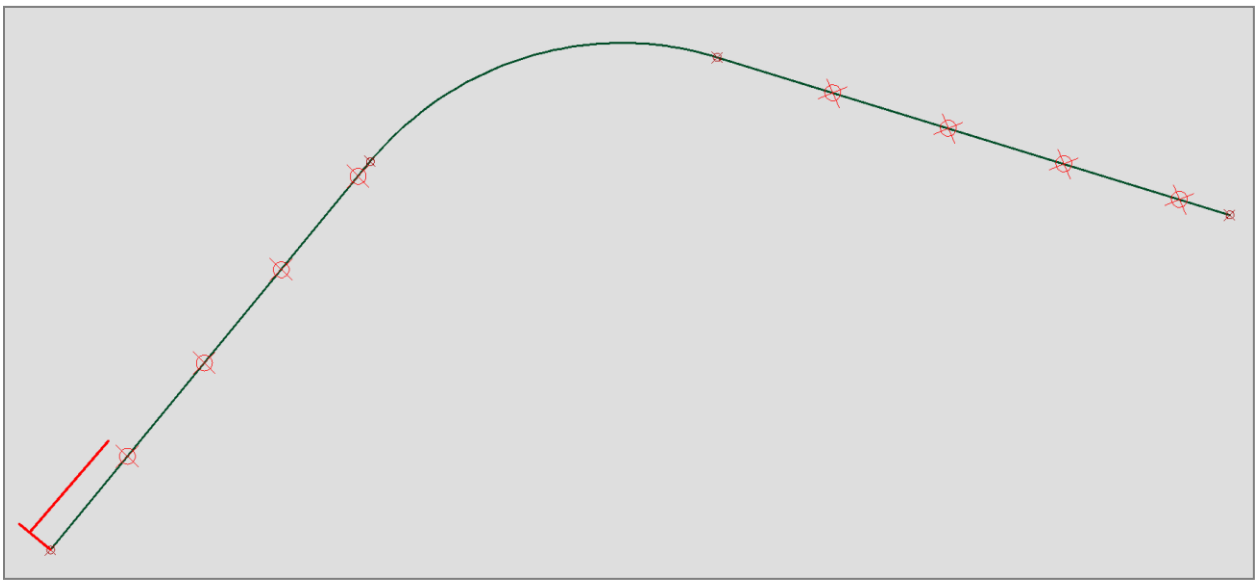

Figure 1.44 - Supplementing in Straight Segments

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The treatment of the arc revolves around the application of a ***mid-ordinate distance***, the *deflection of the arc from its chord measured at and perpendicular to the midpoint of the chord*. The definition of a polyline arc in AutoCAD uses this measurement, shown dashed in red in Figure 1.45, and this is why no vertices are present around the arc. The ***Supplementing Mid-Ordinate Distance*** in Civil 3D specifies a new shorter chord as seen in the Figure; where this chord hits the arc a new vertex is added, and the same new chord length is repeated along each arc found to supplement vertices to allow the TIN to include the arcs.

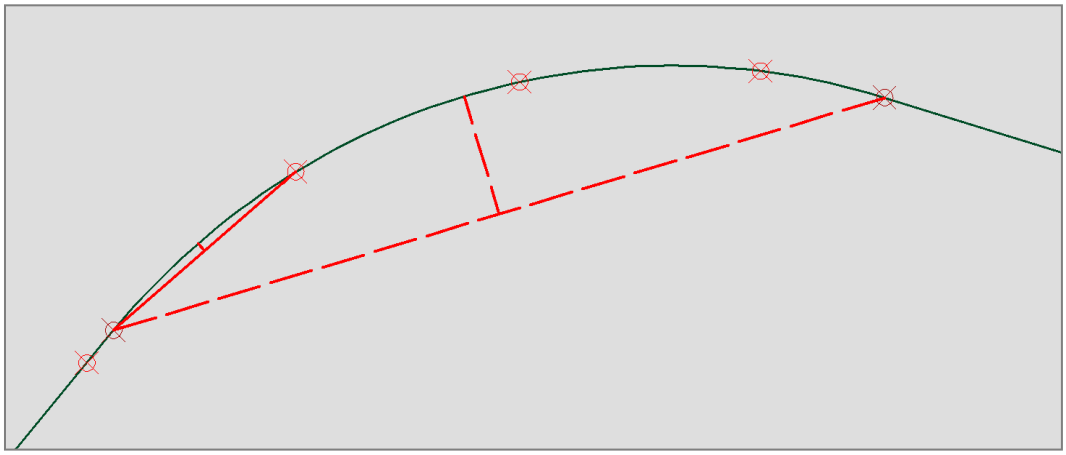


Figure 1.45 - Supplementing in Arcs

The challenge again in working with Civil 3D is to come up with numbers for contour supplementing for the dialog box. For sites ranging in size from 10 to 250 acres a good rule of thumb is 100' of supplementing distance and 2' of mid-ordinate distance. The numbers again can be decreased for smaller sites and increased for larger ones.

Minimizing Flat Areas

The lower half of the *Add Contour Data* dialog supplies for options to ***Minimize flat areas***. These options control the application of a new concept for Autodesk products found in Civil 3D, ***Surface Trending***. Surface Trending attempts to minimize flat areas formed by TIN triangles jumping across contours, rather than by projecting from the bulge in a contour to the next higher or lower elevation. Flat areas formed in TIN's lead to "steps" in profiles and sections, and are the reason why contours formed from TIN's in Land Desktop often did not match the contours from which the TIN was produced.

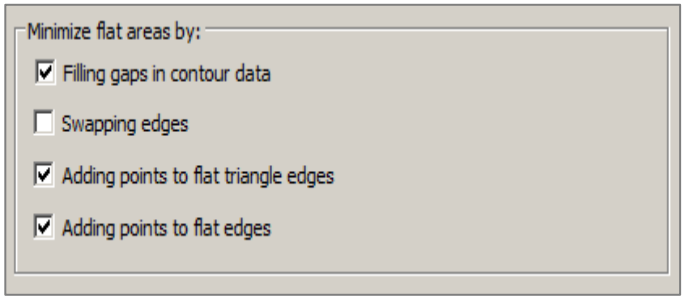


Figure 1.46 - Minimize Flat Area Options

The best guidance for building an ***Existing*** surface from contours is to accept the defaults in the *Add Contour Data* dialog, leaving **Filling gaps in contour data**, **Adding points to flat triangle edges** and **Adding points to flat edges** each **On**, but leaving **Swapping Edges Off**. Turning on *Swapping Edges* slows the processing of the TIN significantly, and additional flipped faces are often not worth the overhead. It is better to examine the TIN with the defaults processed, and then rebuild with the fourth option enabled if desired.

It should also be noted that ***None*** of the *Minimize flat areas* options should be used in building a ***Proposed*** TIN from contours. The use of Surface Trending with a proposed TIN would radically alter the TIN shape from what is desired. An example of the result of Surface Trending is coming later in the example.

Never use the Minimize Flat Areas options in building a proposed TIN from contours.

Returning to the selection of data for this surface, the **Description** is entered, the **Weeding Distance** and **Angle** values supplied, the **Supplementing Distance** and **Mid-Ordinate distance** supplied, and the **Minimize flat areas** settings left in their defaults. Press **OK** to select the contours.

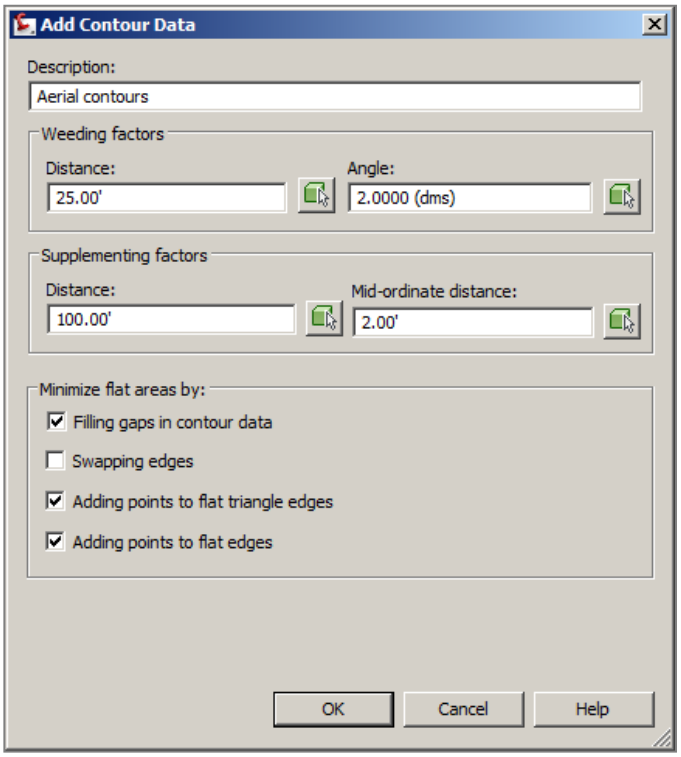


Figure 1.47 - Add Contour Dialog Settings in Example

At the `Select contours:` prompt type **'LA** and press **Enter**, displaying the *Layer Properties Manager* again. In the *Layer Properties Manager,* turn off all layers except the contours - R-CONTOURS 2 and R-CONTOURS 10 in this case. Press **OK** to exit the *Layer Properties Manager,* returning to the `Select contours:` prompt.

Select all of the contours with a **Window** or **Crossing** selection, ***but do not hit Enter to close the selection***.

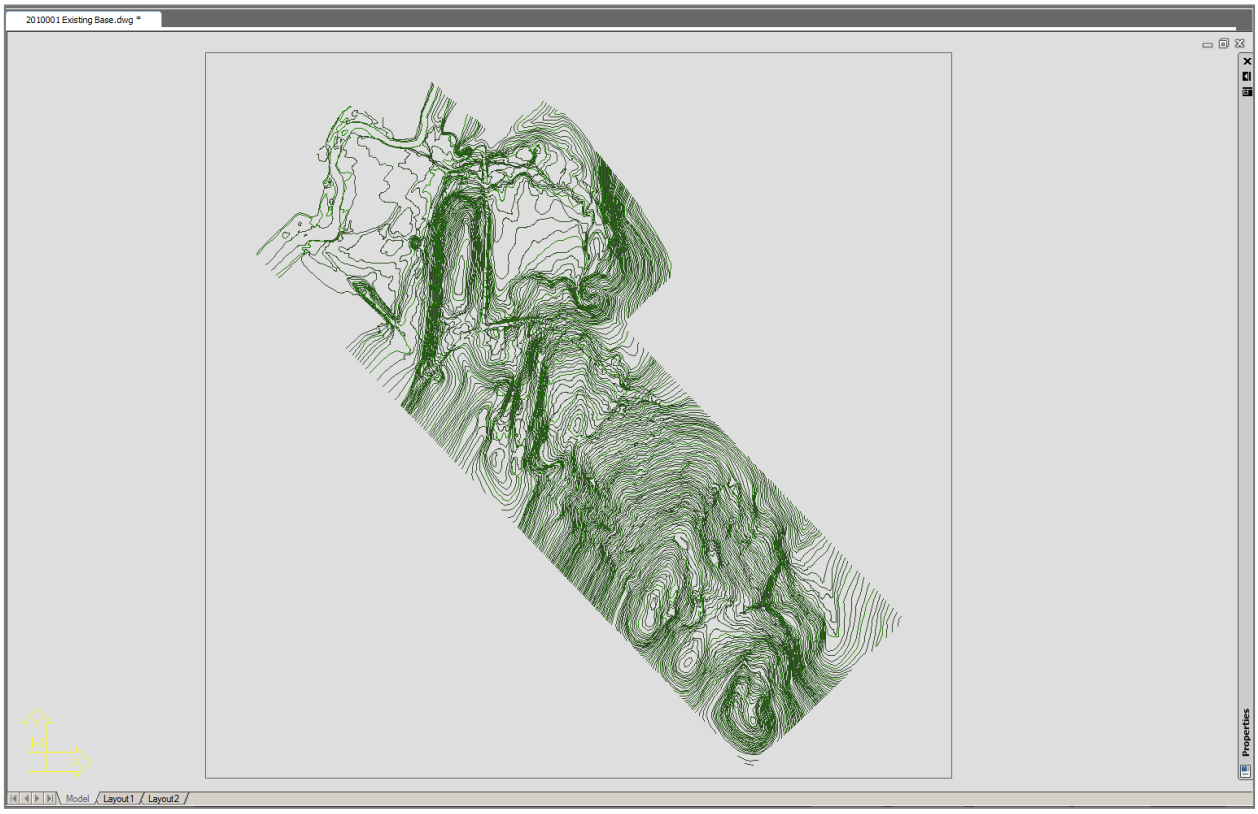
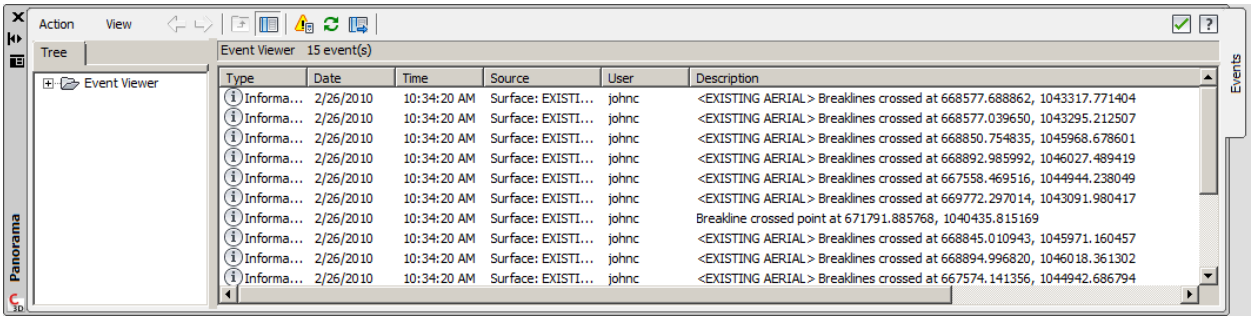


Figure 1.48 - Selecting Spot Elevations with Crossing

AutoCAD is still at the `Select objects:` prompt; again type **'LA** and press **ENTER** to redisplay the *Layer Properties Manager*. Turn the layers back on (or again restore a layer snapshot), and again press **OK** to exit the *Layer Properties Manager* and return to the `Select objects:` prompt.

Press **ENTER** to end the selection, and Civil 3D rebuilds the surface, adding the contour data.

The updated TIN will display in the drawing, and the **EVENT VIEWER** should appear.



Type	Date	Time	Source	User	Description
Informa...	2/26/2010	10:34:20 AM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 668577.688862, 1043317.771404
Informa...	2/26/2010	10:34:20 AM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 668577.039650, 1043295.212507
Informa...	2/26/2010	10:34:20 AM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 668850.754835, 1045968.678601
Informa...	2/26/2010	10:34:20 AM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 668892.985992, 1046027.489419
Informa...	2/26/2010	10:34:20 AM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 667558.469516, 1044944.238049
Informa...	2/26/2010	10:34:20 AM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 669772.297014, 1043091.980417
Informa...	2/26/2010	10:34:20 AM	Surface: EXISTI...	johnc	Breakline crossed point at 671791.885768, 1040435.815169
Informa...	2/26/2010	10:34:20 AM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 668845.010943, 1045971.160457
Informa...	2/26/2010	10:34:20 AM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 668894.996820, 1046018.361302
Informa...	2/26/2010	10:34:20 AM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 667574.141356, 1044942.686794

Figure 1.49 - Event Viewer

The appearance of the Event Viewer announces the fact that TIN triangles already formed have been crossed by the addition of the second set of data, the *Crossing Breaklines* setting discussed earlier. Had this setting under *Surface Feature Settings* not been made, the Event Viewer would be full of error messages and the TIN would look significantly different - missing most of the contour data in fact.

Before dismissing the Event Viewer clear it; use the **ACTION** pulldown within the Event Viewer itself and select **CLEAR ALL EVENTS**. Then **CLOSE** the Event Viewer with the ☑ in its upper corner.

This is also a good time to **SAVE** the drawing.

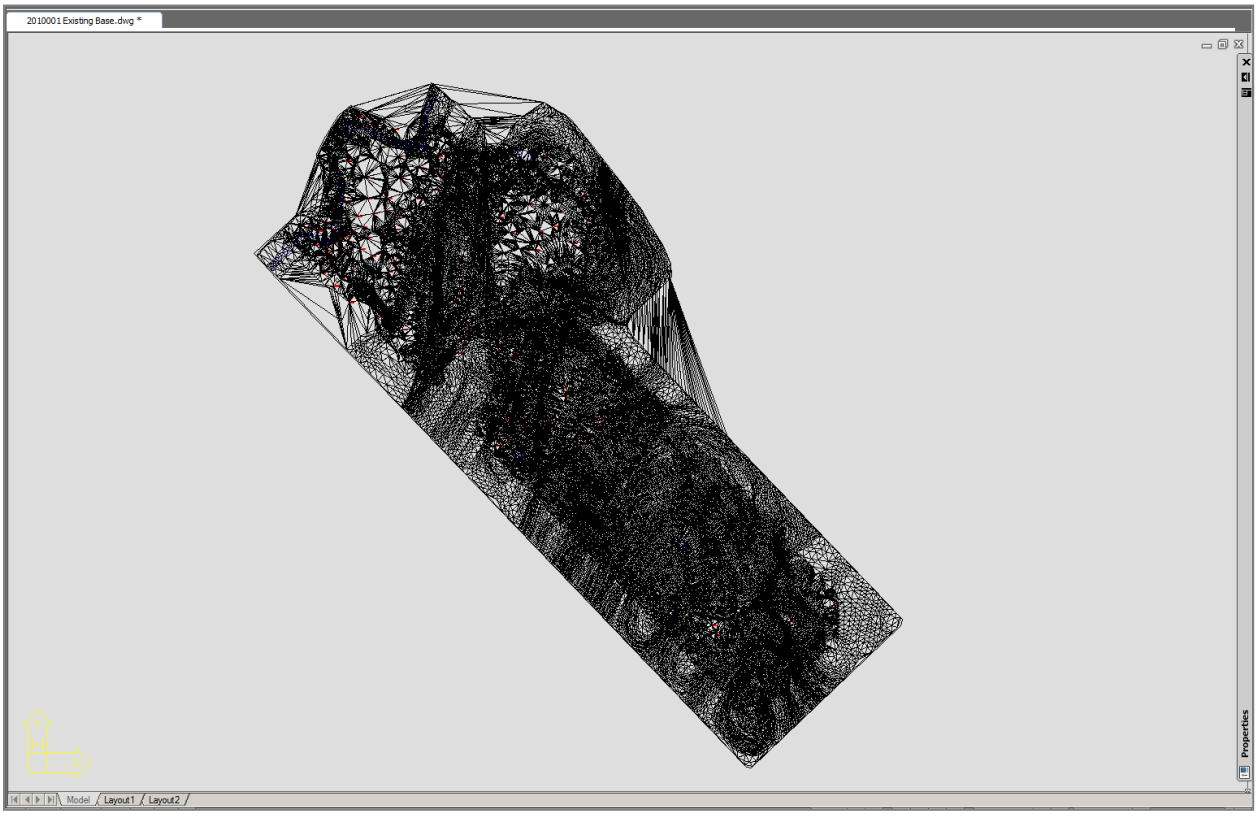


Figure 1.50 - Surface After Addition of Contour Data

Adding Breakline Data to the Surface

Breaklines are essential in the preparation of an accurate surface, and are necessary to correctly illustrate features that have their own grade characteristics, such as the edge of a road.

Creating Breaklines from Drawing Information

While there are edges of roads in the example aerial, they will actually be replaced by surveyed field work for the two main roads involved, to be supplied as points and breaklines in a later chapter. One location where breaklines would still potentially be useful would be in the streams, shown in this drawing as 2D polyline features. The edges of stream could be important in the surface if HEC-RAS sections were to be prepared from it using tools in Smartdraft, though an additional breakline would be required for the thalweg of the stream to correctly shape it in the surface. In any event, breaklines often need to be prepared from plan features such as those provided, and the trick is how to accomplish it.

Looking at an area where the breaklines are needed, one can see how the blue edge of stream in the drawing meanders from contour to contour. The elevation where the edge crosses the contour can be determined, and a *3D Polyline* could be drawn starting from there. The problem is that there are quite a few vertices required before reaching a known elevation at the next contour crossing, and the elevation of each vertex would have to be interpolated as the polyline is drawn.

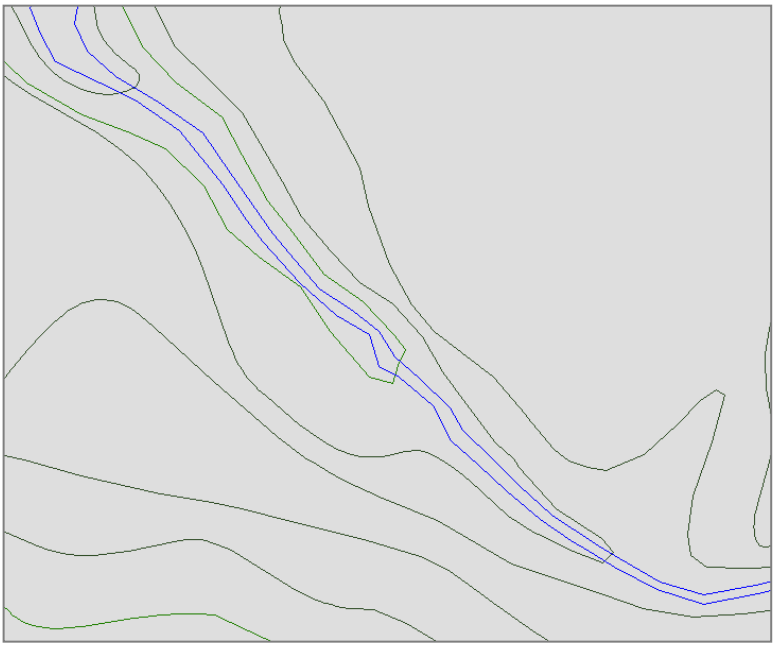


Figure 1.63 - Blue Edge of Water Crossing Contours

There is a tool in Civil 3D that can actually handle this interpolation in a somewhat automated fashion, and can be used to ultimately produce a 3D Polyline usable as a breakline in the existing surface. The command is actually a ***Grading*** command that produces a Civil 3D ***Feature Line***, but a Feature Line, when exploded, becomes a 3D Polyline, exactly what we want at this point.

Some setup in preparation for drawing the breaklines is required.

There is a R-FEATURES layer in the drawing; the features or breaklines for the aerial should really be on this layer, so make it **CURRENT** (it may be frozen).

Several running **OSNAPS** will be required in this exercise: turn on running **OSNAPS** of **ENDPOINT** and **NEAREST**, clearing any other that may be on.

ZOOM in to an area where breaklines are needed.

If working with the aerial drawing supplied in the dataset, careful inspection of the R-FEATURES layer will reveal that most of the breaklines are actually there!

To begin, a command will be selected from the Ribbon. From the **HOME** Tab, **CREATE DESIGN** Panel, open the **FEATURE LINE** Dropdown and pick **CREATE FEATURE LINE**.

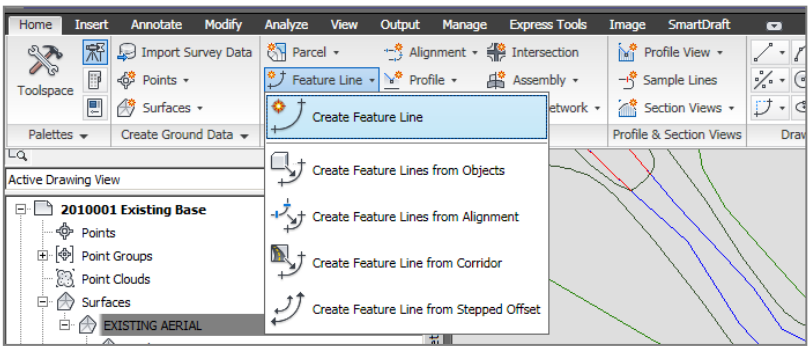


Figure 1.64 - Create Figure Line command in Ribbon

The *Create Feature Lines* dialog displays, with way more options than are needed in this case.

Each Feature Line in Civil 3D needs to be contained in a *Site*. Sites have no bearing on what we're doing here, and we really don't want to spend time on their definition, so leave the **SITE** set to the default.

Sites are geospatial envelopes serving as the containers for interrelated alignments, parcels and grading. Yeah, we'll leave that for another day.

The **NAME** can turned **OFF**, and the **STYLE** turned **OFF**. The **LAYER** option can be changed to **USE CURRENT LAYER**.

Press **OK** from the dialog.

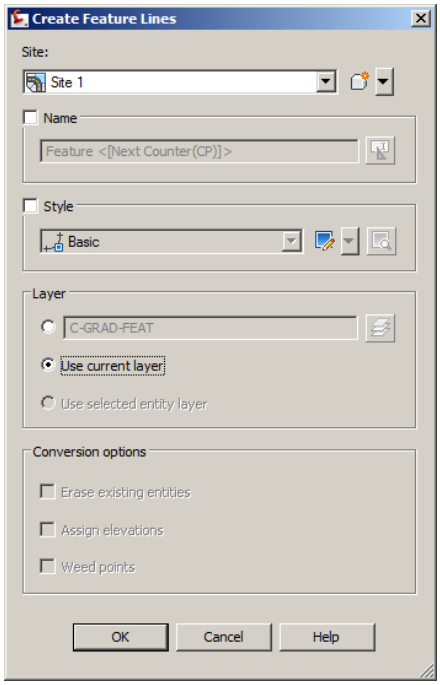


Figure 1.65 - Create Figure Lines Dialog

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The command prompts `Specify start point:`, and things now start getting tricky. The intent is to start a piece of the breakline where the edge of stream crosses a contour, indicated by the red circle in Figure 1.66. The problem is that this picked point must use the elevation of the contour itself, and that is no small trick in AutoCAD. The point cannot be picked with an Intersection snap (INT), as there is no intersection due to the objects being at different elevations. The use of an Apparent Intersection snap (APPINT) won't work as planned either, as AutoCAD would insist on using the elevation of the object with a Z of 0; not what we want.

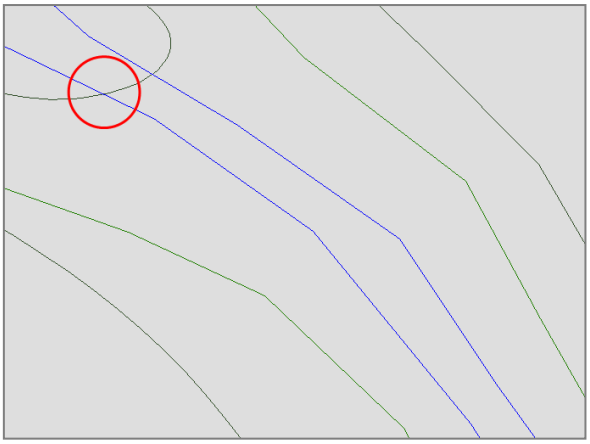

Figure 1.66 - Location for Picked Vertex on Breakline

The solution is to use another old trick in AutoCAD, a ***.XY*** filter, which instructs AutoCAD to use only the X and Y coordinate of a picked point, and to get the Z from somewhere else. At the `Specify start point:` prompt type **.XY** and press **ENTER**. AutoCAD prompts `Specify start point:.xy of`; pick the place where the stream and contour cross; an APPINT snap can be used, but it's overkill. With the point picked, AutoCAD prompts `(need Z):`; place the cursor anywhere on the contour, allowing the running OSNAP to lock it on the contour and pick; AutoCAD will read the elevation from the contour and echo it at the prompt, press **ENTER**.

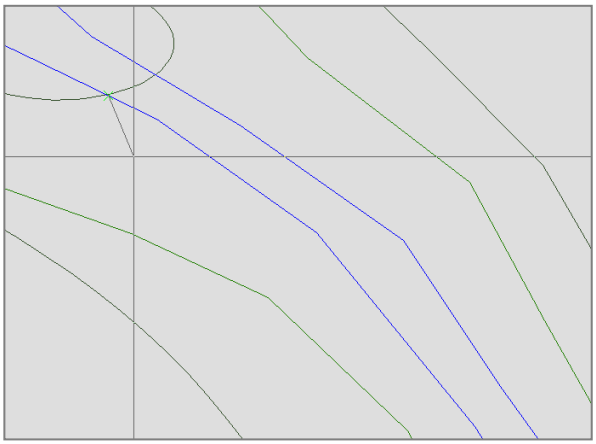

Figure 1.67 - Cursor After Picking with .XY

This gets the Feature Line started, at the elevation of the contour. It's going to get tricky (trickier) from here, so watch the command line options.

The command should be prompting `Specify the next point or [Arc]:` Move down the feature slightly to the next vertex along it to be used, and **PICK**. The running *Endpoint* and *Nearest* snaps should make this easy.

The command will prompt `Specify elevation or [Grade/SLope/Difference/SUrface/Transition] <178.00>:` offering the last elevation used. The elevation at this picked point is ***not*** known; we want the program to ***interpolate*** this elevation based on the next known elevation we give it. ***To start this interpolation mode***, type **T** for **TRANSITION** at this prompt and press **ENTER**.

Move along the feature and pick the next desired vertex. The command now `prompts Transition or Grade/SLope/Elevation/Difference/SUrface] <Transition>:`. Since we need to remain in the *Transition* mode until the next known elevation, press **ENTER**, as **TRANSITION** has now become the default option on the command line.

Continue picking vertices along the feature, and remembering to hit **ENTER** for **TRANSITION** at each picked point, until ***just before*** the next location where an elevation is to be specified (the next contour crossing).

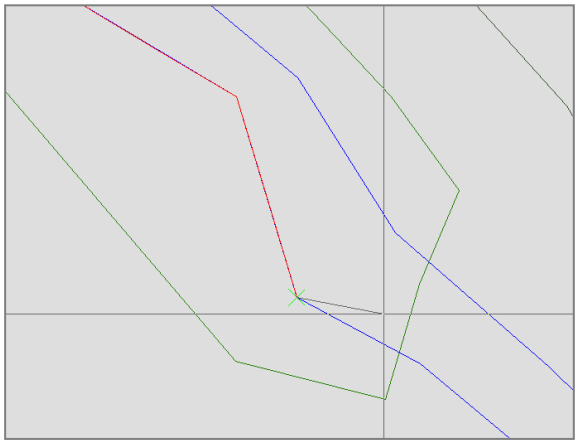

Figure 1.68 - Approaching Next Contour

Don't forget to hit Enter for Transition for each picked point, or this is going to get ugly.

In Figure 1.68 we've come up on another contour, so some more hocus-pocus is due.

To deal with the known elevation at the contour crossing, again type **.XY** and **ENTER** prior to picking at the contour crossing. Once the crossing is picked, again pick right on the contour to satisfy the `Need Z:` prompt.

The command will now prompt:

```
Specify the next point or [Arc/Length/Close/Undo]: .xy of _non (need Z):
Distance 116.36',  Grade 1.72,  Slope 58.18:1,  Elevation 180.00'
Transition or [Grade/SLope/Elevation/Difference/SUrface] <Transition>:
```

The elevation read is at the command line, but one line up from the current command. Type **E** for **ELEVATION** to use the elevation value read for this picked vertex, and **ENTER** to confirm the Elevation.. The command uses the original elevation for the first vertex, this picked elevation for the last vertex, and interpolates all elevations in between!

That elevation wouldn't even show up if the command line was off and Dynamic Input was the only command interface being used.

At this point, continue in the command, picking the next vertex and returning to the **TRANSITION** mode by typing **T**. Don't try to go too far, however; it's better to build bunch of these rather than trying to do one long one.

Also be very careful of the Undo option in the main command line: `Specify the next point or [Arc/Length/Close/Undo]:`. When you get buggered up in the command it seems like it would be easy to back up on vertex at a time with the Undo option. In reality the Undo option hoses the transition totally. Better to either pull-up and start again, or hope for the best and finish where you are, hopefully cleaning up a vertex turning toward the center of the earth in AutoCAD. The command is unforgiving, and won't let you out without specifying an elevation for the current segment.

When you've run along the feature as long as you need or as long as you dare, end the command with an extra **ENTER** at the command prompt.

Figure 1.69 - Segment of Feature Line Drawn in this Example

Before adding the Feature Line to the surface, it would be helpful to make sure it is correct. This can be easily accomplished by using one of the ***Contextual Tabs*** in the Ribbon.

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Click on the Feature Line to display its **Grips**. As the **Feature Line** *Contextual Tab* appears, move to its **Edit Elevations** tab, and pick **Elevation Editor**.

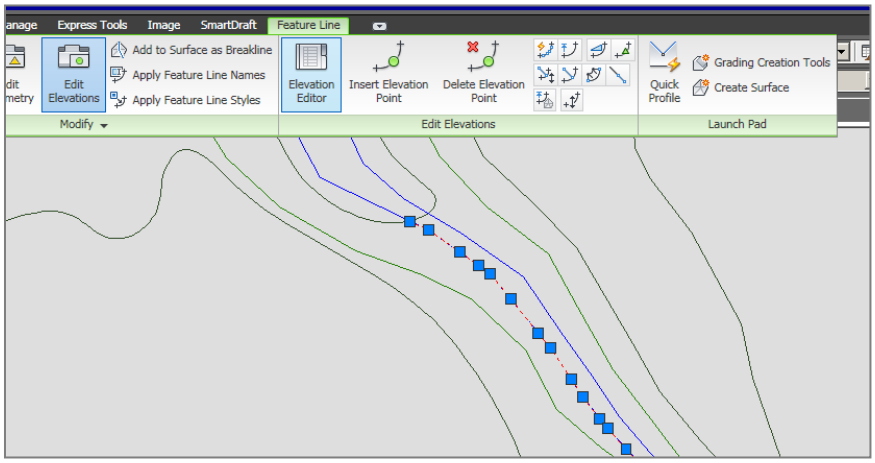
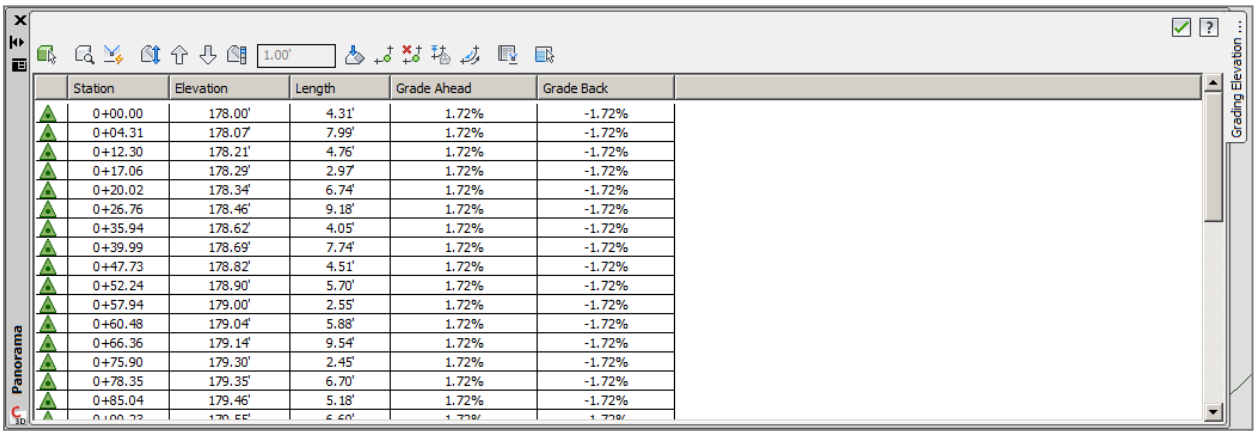


Figure 1.70 - Feature Line Contextual Tab in Ribbon

The Feature Line elevations display in the *Grading Elevation Editor*, which is a tab in the Panorama. Scroll through the elevations, making sure there is nothing unexpected. Bad elevations could be edited here, but frankly if the Feature Line is buggered up it's usually better to erase it and start again.



Station	Elevation	Length	Grade Ahead	Grade Back
0+00.00	178.00'	4.31'	1.72%	-1.72%
0+04.31	178.07'	7.99'	1.72%	-1.72%
0+12.30	178.21'	4.76'	1.72%	-1.72%
0+17.06	178.29'	2.97'	1.72%	-1.72%
0+20.02	178.34'	6.74'	1.72%	-1.72%
0+26.76	178.46'	9.18'	1.72%	-1.72%
0+35.94	178.62'	4.05'	1.72%	-1.72%
0+39.99	178.69'	7.74'	1.72%	-1.72%
0+47.73	178.82'	4.51'	1.72%	-1.72%
0+52.24	178.90'	5.70'	1.72%	-1.72%
0+57.94	179.00'	2.55'	1.72%	-1.72%
0+60.48	179.04'	5.88'	1.72%	-1.72%
0+66.36	179.14'	9.54'	1.72%	-1.72%
0+75.90	179.30'	2.45'	1.72%	-1.72%
0+78.35	179.35'	6.70'	1.72%	-1.72%
0+85.04	179.46'	5.18'	1.72%	-1.72%

Figure 1.71 - Feature Line Elevations in Grading Elevation Editor

Satisfied that the elevations are (hopefully) fine, close the *Grading Elevation Editor* with the button in its corner.

The process used to create the breakline has produced a Civil 3D Feature Line. The Feature Line itself is overkill at this point, and will just create complication in the Prospector later. Sacrifice the Feature Line at this point by **EXPLODING** it in AutoCAD; the exploded Feature Line is a 3D Polyline, the preferred vehicle for a breakline.

Repeat this process until all breaklines needed in the drawing have been produced.

There will actually be only two that need to be created in the example drawing. You're welcome.

Be sure to **Save** the drawing when all breaklines are created.

Adding Breaklines to the Surface

Before adding the breaklines to the surface, change the **SURFACE STYLE** back to *Triangles Only* in **SURFACE PROPERTIES.** This will make the impact of the additional breaklines easier to see.

The impact of the added breaklines will be most evident in the northwestern most portion of the site, where there is a major stream which is presently not visible in the TIN triangles. The TIN crosses over the edges of the stream with no knowledge of its existence, as seen in Figure 1.72.

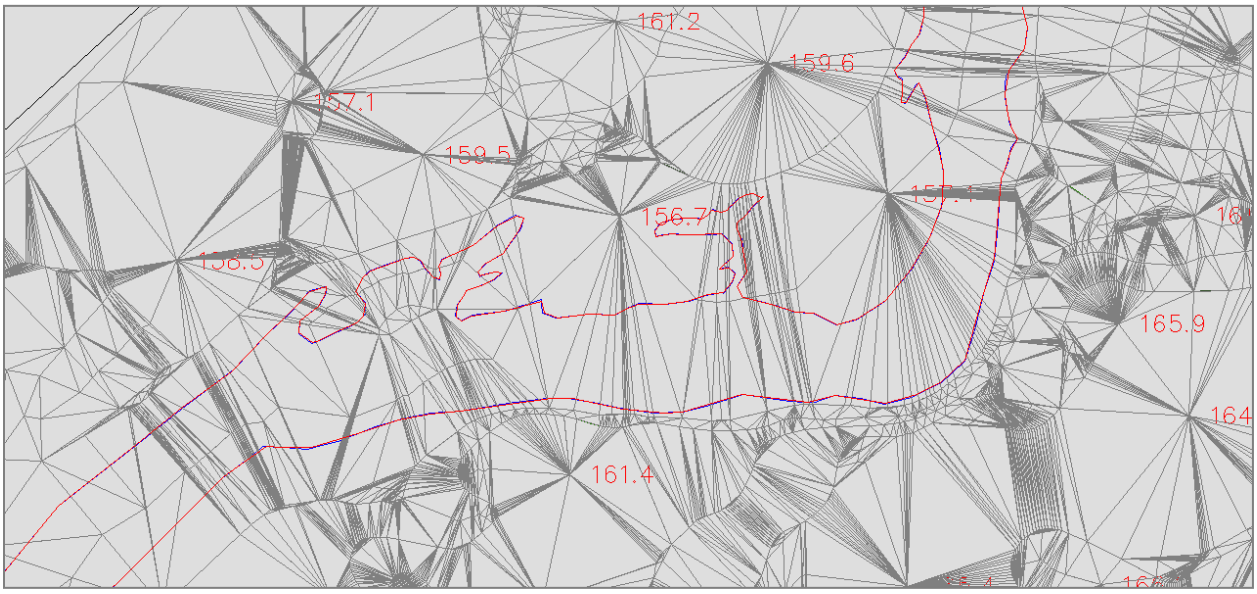


Figure 1.72 - TIN Crossing Over Edges of Stream

The color of the TIN has been changed by changing the color of its layer of insertion.

To add the breaklines to the surface, **RIGHT-CLICK** on **BREAKLINES** under the **DEFINITION** level for the EXISTING AERIAL surface, and pick **ADD** from the menu.

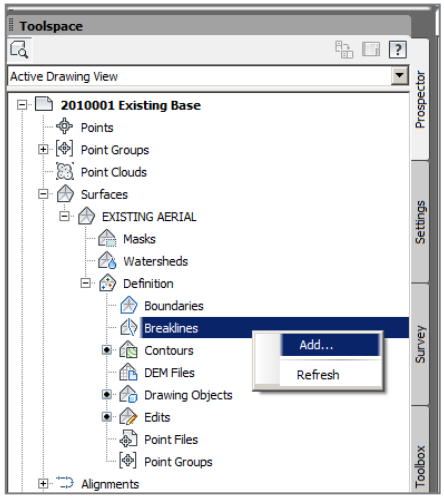


Figure 1.73 - Add Breaklines from Prospector

The *Add Breaklines* dialog displays. Enter a **DESCRIPTION** as appropriate. The breakline type will be **STANDARD**, since the objects to be selected are 3D Polylines.

The other breakline types are explored in later chapters.

The **WEEDING FACTORS** and **SUPPLEMENTING FACTORS** can be left **OFF**; these can be used to modify the number of vertices along the breaklines in the same manner as for contour data.

Press **OK** from the dialog.

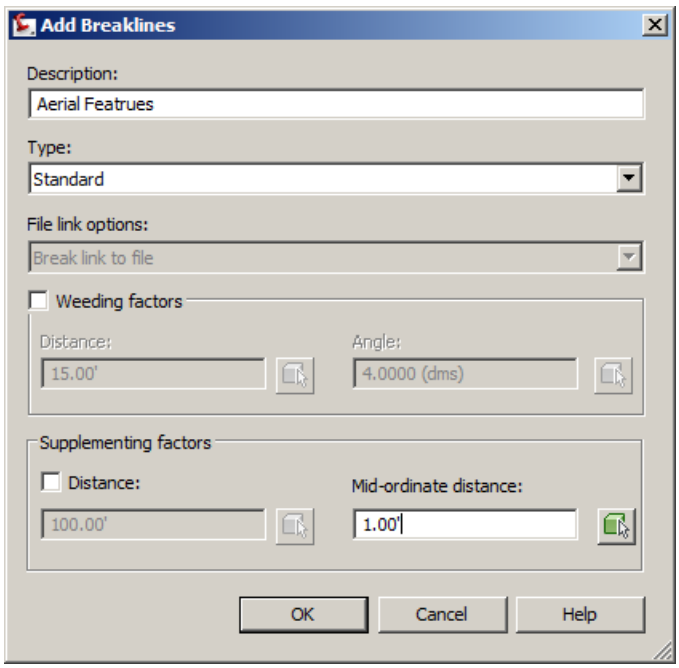


Figure 1.74 - Add Breaklines Dialog Settings in Example

At the `Select Objects:` prompt use the same transparent layer magic with **'LA** to turn off the layers other than the breaklines, **SELECT** the breaklines, then again use **'LA** and turn the layers back on. After pressing **ENTER** to end the selection the surface is rebuilt.

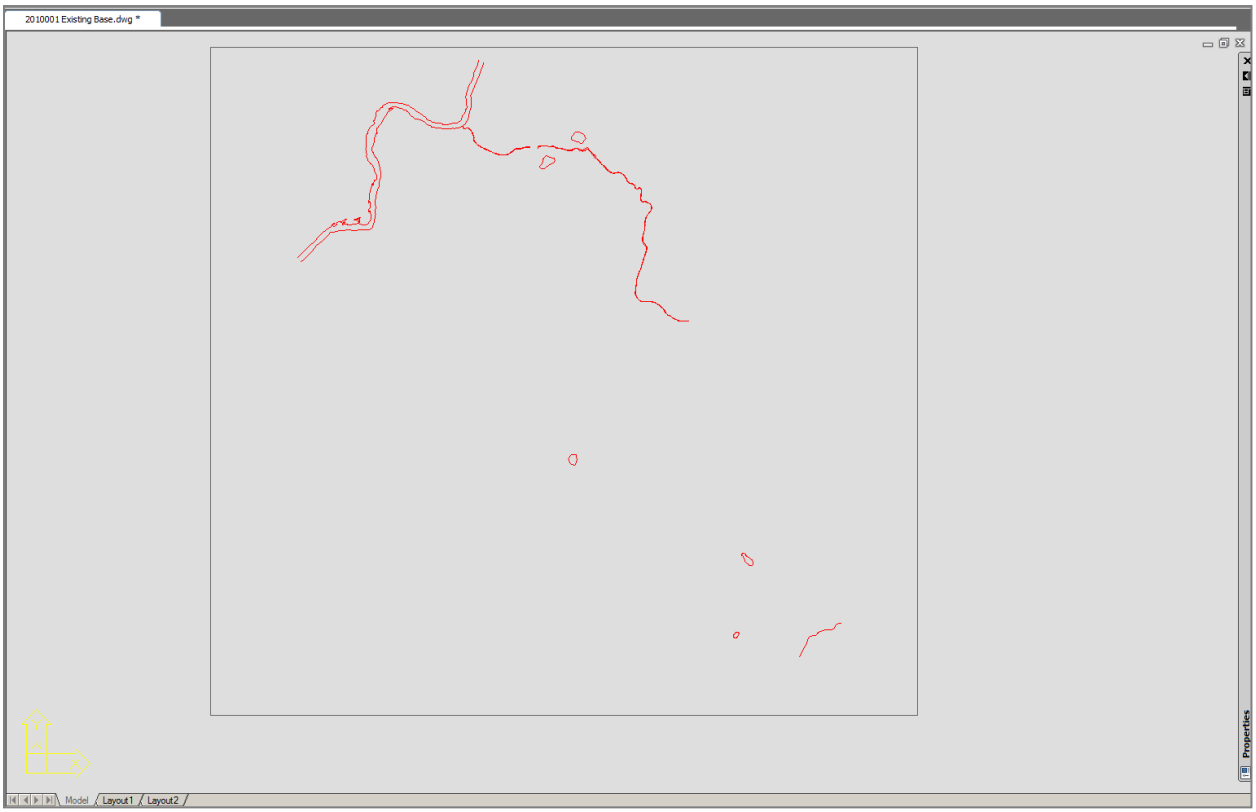
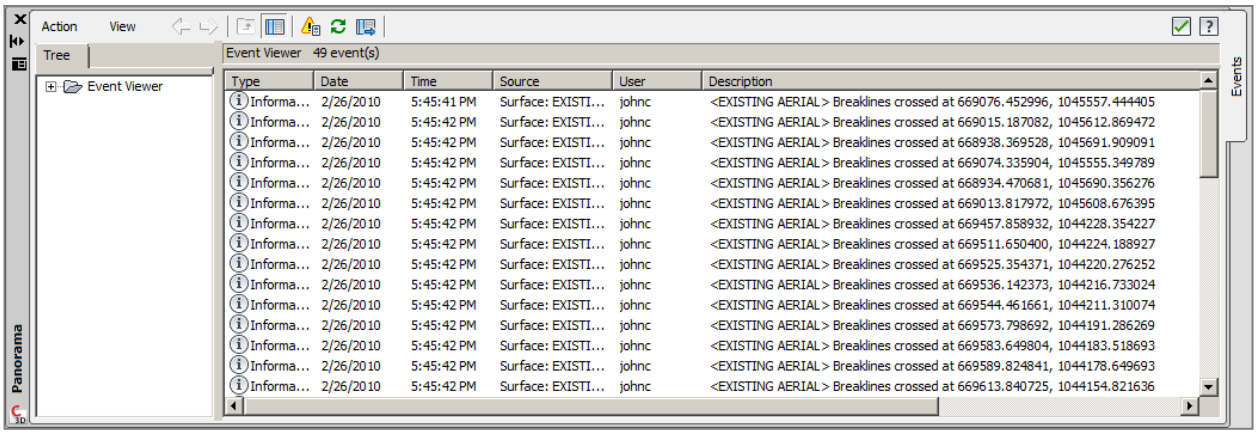


Figure 1.75 - Selecting Breaklines with Crossing

The updated TIN will display in the drawing, and the **EVENT VIEWER** should again appear.



Type	Date	Time	Source	User	Description
Informa...	2/26/2010	5:45:41 PM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 669076.452996, 1045557.444405
Informa...	2/26/2010	5:45:42 PM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 669015.187082, 1045612.869472
Informa...	2/26/2010	5:45:42 PM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 668938.369528, 1045691.909091
Informa...	2/26/2010	5:45:42 PM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 669074.335904, 1045555.349789
Informa...	2/26/2010	5:45:42 PM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 668934.470681, 1045690.356276
Informa...	2/26/2010	5:45:42 PM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 669013.817972, 1045608.676395
Informa...	2/26/2010	5:45:42 PM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 669457.858932, 1044228.354227
Informa...	2/26/2010	5:45:42 PM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 669511.650400, 1044224.188927
Informa...	2/26/2010	5:45:42 PM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 669525.354371, 1044220.276252
Informa...	2/26/2010	5:45:42 PM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 669536.142373, 1044216.733024
Informa...	2/26/2010	5:45:42 PM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 669544.461661, 1044211.310074
Informa...	2/26/2010	5:45:42 PM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 669573.798692, 1044191.286269
Informa...	2/26/2010	5:45:42 PM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 669583.649804, 1044183.518693
Informa...	2/26/2010	5:45:42 PM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 669589.824841, 1044178.649693
Informa...	2/26/2010	5:45:42 PM	Surface: EXISTI...	johnc	<EXISTING AERIAL> Breaklines crossed at 669613.840725, 1044154.821636

Figure 1.76 - Event Viewer

The appearance of the Event Viewer again announces the fact that TIN triangles already formed have been crossed by the addition of the third set of data, the *Crossing Breaklines* setting discussed earlier.

Before dismissing the Event Viewer clear it; use the **ACTION** pulldown within the Event Viewer itself and select **CLEAR ALL EVENTS**. Then **CLOSE** the Event Viewer with the ☑ in its upper corner.

Returning to a view of the surface again in the northwest corner of the site, notice how the TIN Triangles, which previously crossed over the stream now have been re-triangulated to include it. The breaklines have clearly worked as expected.

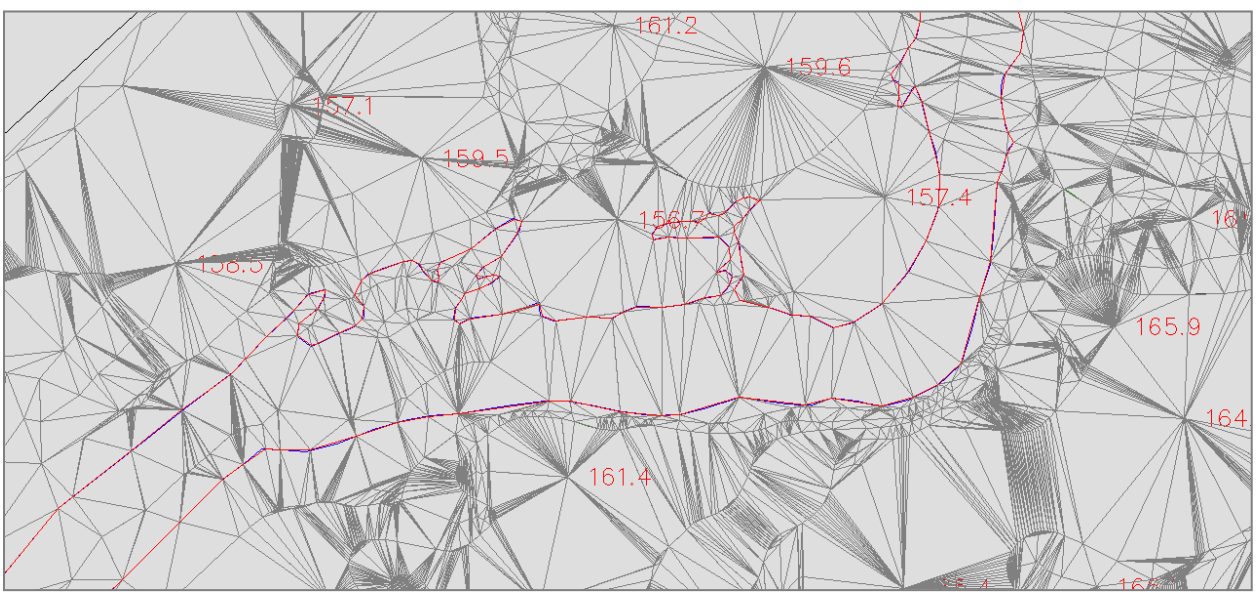


Figure 1.77 - TIN Crossing Incorporating Edges of Stream

Again, this is a good time to **SAVE** the drawing.

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Surface Integrity and Data Security

With the breaklines added to the surface, some thought should be given to the management of the drawing, and its anticipated uses. This is the Existing Base drawing, which will be Xref'd into the overall drawing set to display existing conditions. Many of the existing features will become start points for proposed features, perhaps being offset or otherwise manipulated in AutoCAD. The breaklines produced are 3D duplicates of features already visible in the drawing as 2D objects, and their duplicate presence would seem unnecessary. 3D polylines are often troublesome in a drawing as they cannot be offset, and are hard to manipulate. In earlier Civil applications, including Land Desktop, when breaklines were defined they were added to a breakline database, and the original 3D polylines could be erased to reduce the drawing size…..

Civil 3D is different. ***There is no database for the breaklines***, in fact, ***there is no database for the surface***. Moreover, ***everything in the surface continues to be dynamically linked to the objects from which it was produced***. If the breakline 3D polylines are erased (or exploded), the breaklines will be removed from the surface and the surface will be rebuilt. Care must be taken in Civil 3D to insure that the objects from which the surface (or other Civil objects) are produced remain in the drawing, intact. This situation extends as well to the aerial contours. In spite of the fact that the surface can now be displayed as contours, the original contours must remain in the drawing. This becomes part of the impetus for use of a Civil Project; using a project, this drawing can be isolated from others in the set, but this surface shared with other drawings with far less overhead. More on that in later chapters.

Several other related concepts come in to play in dealing with the data integrity we're discussing.

Surfaces, like most Civil Objects, can be ***locked*** to prevent accidental edits and unintended updates. Surfaces should be locked to protect them, and we'll deal with surface locking shortly, after we do some TIN editing.

The updating of surfaces can be controlled, and updates are managed through the **REBUILD** options available by **RIGHT-CLICKING** on the surface name in the Prospector. The surface will always *Rebuild* when new data are added. Whether or not it *Rebuilds* at other times, including when underlying data disappear, is controlled by the *Rebuild Automatic* setting in the Prospector. For the time being we've left **REBUILD AUTOMATIC OFF**; if Civil 3D sensed that the surface needed to be rebuilt it would communicate it by placing a glyph before the surface name. That glyph can be misleading, and we'll talk about it, and the Rebuild Automatic setting, in a later chapter.

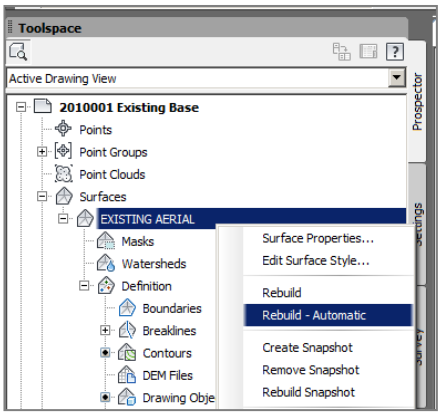


Figure 1.78 - Surface Options

Civil 3D normally links the surface to the full set of underlying data from which the surface is built, providing the dynamic linkage described. An option is to create a *Snapshot* within the surface, which creates a duplicate copy of the underlying surface data and binds it in the surface object. Doing this "protects" the surface; even if Joe Autocad erases the original contours the surface will stay intact. In reality, surface snapshots are not the panacea they seem. Surface snapshots bloat already large drawings to huge proportions, with a concurrent degradation of performance. It's much better ***not to use snapshots***, to make sure the drawing is backed up, and to send Joe Autocad to training.

Surface Editing

The surface, as produced thus far, has some TIN triangles around the outside edge that are wrong, and will need to be cleaned up. These triangles can be affected several ways, by conventional TIN Editing, or by the application of a Boundary. Though we'll eventually add a boundary in this example, we want to talk for just a moment about TIN editing.

In order to edit the TIN the surface must be displayed using a Surface Style that shows the triangles. The triangles can be the only element shown, as is the case at the moment, or the triangles can be shown along with other elements, such as the contours. The *CivilTraining.Com* template drawing includes two *Proposed Contours - Edit Surface* styles that display contours and triangles for this purpose.

The Edit Surface commands themselves can be accessed either of two ways: **RIGHT-CLICKING** on the **EDITS** level below **DEFINITION** below the **SURFACE NAME** reveals an **EDIT SURFACE MENU**, and **CLICKING** on the surface to select it in the drawing displays the **TIN SURFACE** Contextual Tab in the Ribbon, where **EDIT SURFACE** is found on the **MODIFY** Panel. We've managed to show both through the magic of mirrors in Figure 1.79, along with some of the bad triangles that we're after.

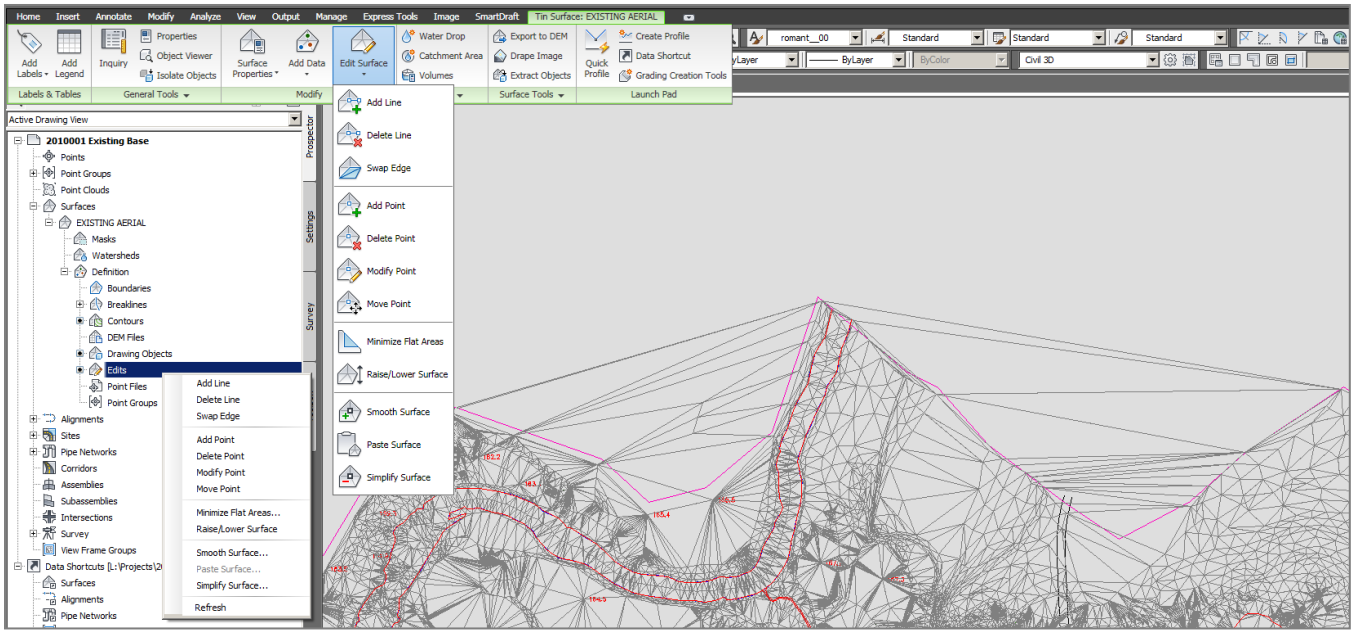


Figure 1.79 - Edit Surface in Prospector and Ribbon

We'll spend more time with other surface edit operations in a later chapter, but the pertinent tool here is *Delete Line*. Picking **DELETE LINE** from either interface takes one to a `Select edges:` prompt; *individual* TIN edges can then be selected in the drawing to be deleted. Curiously, Civil 3D suppresses AutoCAD's Selection Set Automatic here. Picking in blank space in the drawing should start an automatic *Window* or *Crossing*, but doesn't. A **CROSSING** selection can be started within the command by typing **C**, or a **FENCE** selection by typing **F**. The advanced selection options work, but won't start automatically.

Thanks again, Autodesk.

Working around the drawing, as many TIN edges as desired can be cleaned up in this fashion. When done, the surface needs to be saved. Again, since the surface is drawing information, **SAVE** the drawing to save the surface.

Though we're supposed to love the Ribbon, this type of TIN editing is WAY faster if the command is started from the Prospector. To bring up the Contextual Tab, the surface has to be selected in the drawing. To be selected, AutoCAD highlights the surface - that takes time. Then, as each set of TIN lines are deleted, AutoCAD has to update the highlight, taking even more time. Some AutoCAD documentation suggests turning off highlights totally. That's such a bad idea we won't even tell you how to do it.

Adding Boundaries to The Surface

Boundaries can be added to a surface, to suppress the display of some data, to show other data, or to add a hard clip beyond which no data will be added.

The boundary concept has been present in Terrain Modeling for some time, and the basic prerequisite remains the same as in previous versions - ***boundaries need to be closed polylines***, the closed polylines cannot self-intersect, cannot have duplicate vertices, and the closing segment must be formed by the *Close* option in the pline or 3D polyline command, not by snapping back to the original vertex. In fact, some *Data Clip* boundaries in Civil 3D can also be defined from other Civil Objects, including Parcels, Feature Lines or Survey Figures.

The aerial drawing provided includes a good candidate for a surface boundary, the limit of certification provided as a polyline by the aerial company.

To start the application of the boundary, **RIGHT-CLICK** on **BOUNDARIES** below **DEFINITION** below the **SURFACE NAME** and pick **ADD** from the menu. The *Add Boundaries* dialog displays.

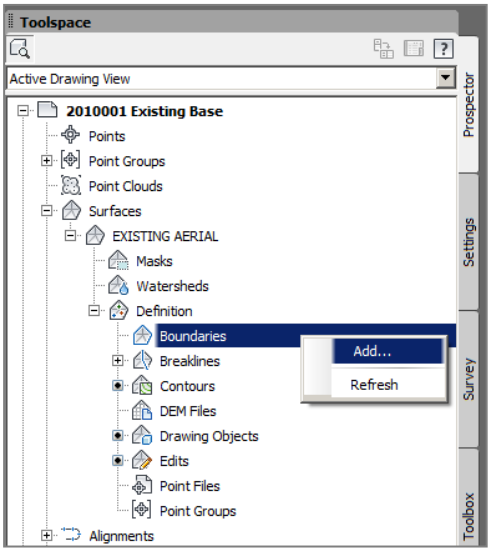


Figure 1.80 Add Boundaries

Supply a **NAME** to identify the boundary.

There are four different types of boundaries that could

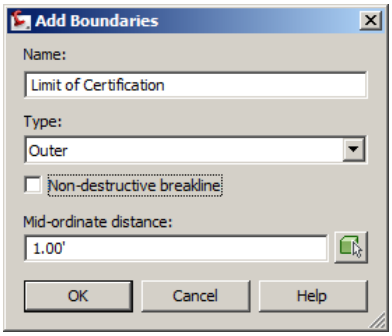


Figure 1.81 - Add Boundaries Dialog

be selected: **Outer**, **Show**, **Hide** and **Data Clip**. A ***Hide*** boundary suppresses the display of TIN data beyond the boundary; the data are still there, but are not shown. A ***Show*** boundary displays the data inside the boundary. An ***Outer*** boundary is the outer-most Hide boundary on the surface; data are still present in the surface beyond the Outer boundary, and additional data can be added beyond it. A ***Data Clip*** boundary suppresses the processing of any data beyond the boundary. No data can be added beyond the data clip, and if an attempt is made to add data beyond the application of the data will be "trimmed" at the clip boundary. As we do not want to necessarily limit the application of data beyond the limit provided, an **Outer** boundary is selected.

The use of a Data Clip here would prevent the addition of more TIN data from GIS beyond the aerial provided, which might be useful in evaluating overall site drainage.

An important concept in the application of the boundary is the possible processing of the boundary as a **Non-destructive breakline**. The Non-destructive breakline setting determines whether each triangle crossed by the breakline will be discarded in its entirety, or whether each will be cut by the boundary and the portion inside the boundary retained. Examining Figure 1.82, notice how certain triangles begin inside the magenta boundary, then run substantially outside it. If the Non-destructive breakline setting is on, the small portion of these triangles inside the boundary would be retained, and a small band of erroneous data added around the periphery of the surface. This band of bogus data could have an impact on a slope analysis performed. As is usually the case with a boundary around the edge of an existing surface, the **Non-destructive breakline** setting here should be **off** to discard these triangles completely.

The **Mid-ordinate** distance in the *Add Boundaries* dialog is used to convert arcs in a boundary to chords for processing; the setting can be ignored as the polyline used does not contain arcs.

Press **OK** to apply the boundary. Like many operations in Civil 3D, a **Regen** may be required to see the result, shown in Figure 1.83.

Save the drawing.

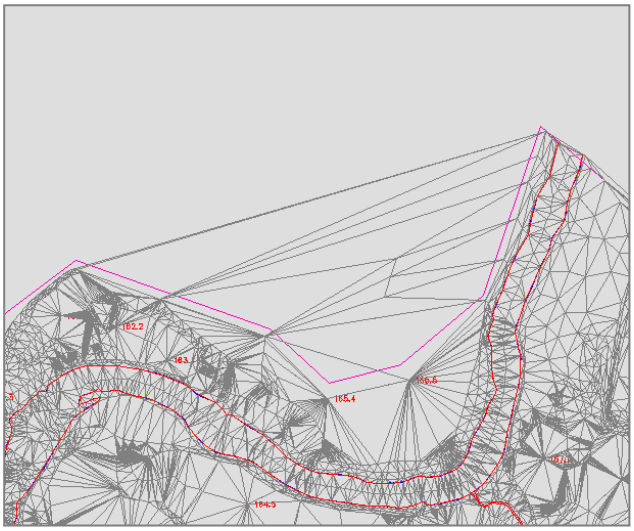


Figure 1.82 - Before Boundary Application

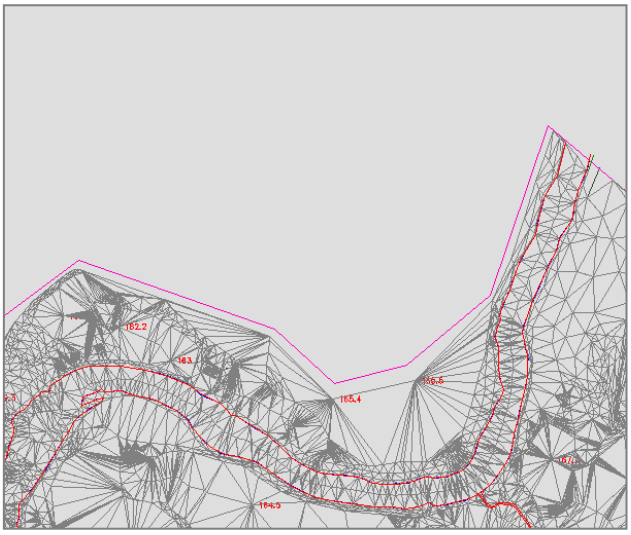


Figure 1.83 - After Boundary Application

Locking The Surface

With the boundary applied, the Existing Aerial surface is complete. A last step is to protect it from accidental editing by Locking.

The surface can be locked several ways, from the Prospector, from the Surface Properties dialog and from the Properties Palette. To lock in the Prospector, **RIGHT-CLICK** on the **SURFACE NAME**, and select **LOCK** from the menu. Once locked, the surface displays the glyph before its name, and will not rebuild or update without being unlocked.

SAVE the drawing.

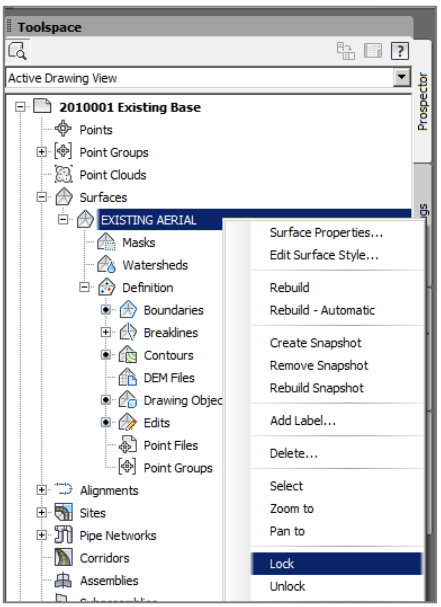


Figure 1.84 - Lock Surface

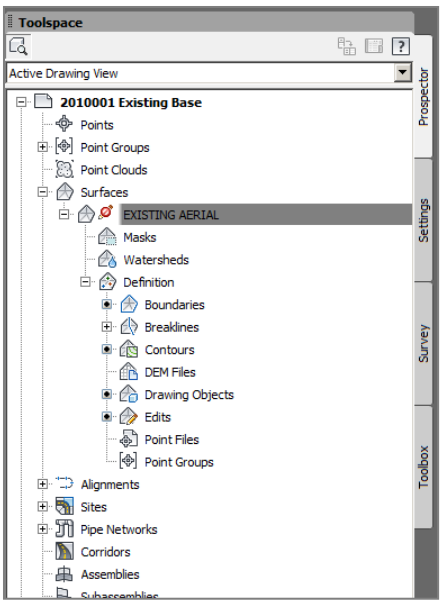


Figure 1.85 Surface Lock Glyph

Always keep surfaces locked in the drawing when not being edited.

Continuing with Additional Field Data

The drawing we're working with here is the Existing Base drawing as it was left at the conclusion of the last section. The drawing contains the points that will be used in the survey surface, and the points themselves are really the only data requirement to move forward. The points can be *Civil 3D Points,* or *Drawing Points*, although the ones here are actually *Survey Points*, having been added to the Survey Point Database at the end of the last chapter. There is no linework through the points for the centerline, edges of pavement, shoulders or bottoms of bank; we're going to develop the linework here for use as breaklines through these features. The Parcel 1, 2 and 3 outbound points are also displayed, although they will not be used in the surface.

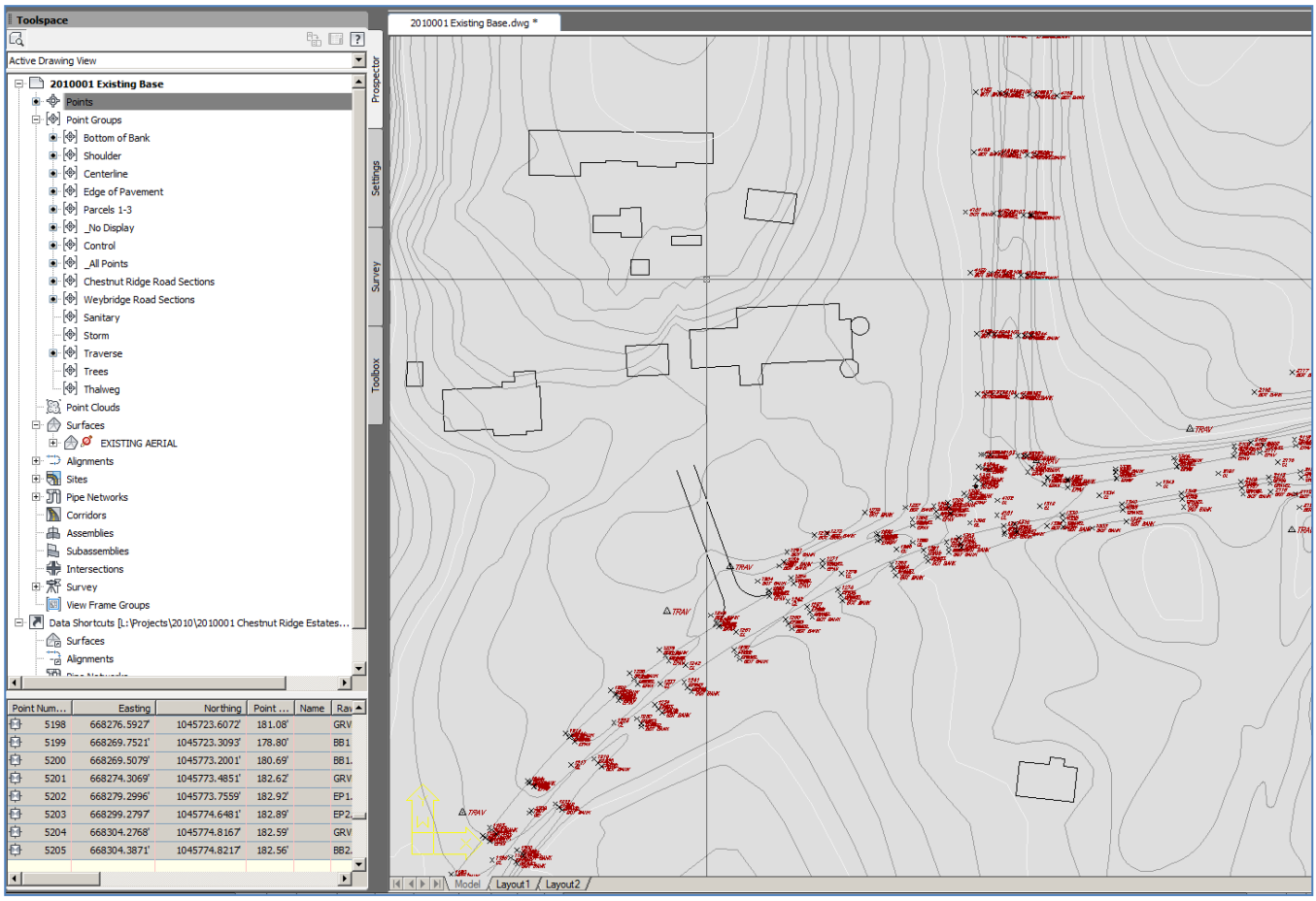


Figure 1.86 - Existing Base Drawing at This Point

The points in the Existing Base drawing are organized in a number of Point Groups as seen in Figure 1.86; these Point Groups provide Overrides which specify the Point Style and Point Object Style necessary for reliable breakline construction as we'll see shortly.

The Existing Base drawing also contains the EXISTING AERIAL surface produced previously from the aerial drawing, and we'll be merging our new survey surface into a copy of this surface shortly. The surface is not visible in the drawing at the moment as its Surface Style is set to _No Display; the contours visible in the drawing presently are the original polyline contours from the aerial drawing.

Creating Breaklines

Since the order in which data are selected for the surface is important, we're going to focus on the breaklines first. The breaklines form the more important data for the surface, generating the overall shape of the surface as defined in this case by the crown, edges of pavement and shoulders, then the individual points deflect the surface up or down within this shape in areas where manholes, water shut offs, inlets or other features are present.

The same points used to create the breaklines will also be added to the surface as points, leading to some duplication of data. This doesn't create any issue, provided the breaklines are created the right way. In fact, once these points are represented by the vertices of the breaklines they need not be added to the surface as point data, but excluding them is usually more trouble than it's worth.

There are a number of ways to create breaklines in Civil 3D. Breaklines can be created directly through tools in the Prospector from drawing entities, polylines and 3D polylines. Breaklines can be generated from the Figures created by the Survey side of Civil 3D, or indirectly from add-on products such as SmartDraft. Compared with Land Desktop, some breakline creation tools seem to be absent, notably *Create by Point* or *Create by Point Number*. This is reflective of a shift in thinking in Civil 3D away from databases and toward drawing data; while breaklines resided in a database in Land Desktop they reside in the drawing in Civil 3D. As such, the primary tool for creating a breakline in Civil 3D is the AutoCAD 3D polyline.

Civil 3D can create an AutoCAD 3D polyline by point number, using the 'PN Transparent command.

Most manual breakline creation in Civil 3D involves the creation of AutoCAD 3D polylines. We're talking here about the basic connect-the-dots type of processing of survey work from points, without any Field-to-Finish automation such as survey figures or SmartDraft. While breaklines could be created through an interface through the Terrain Model Explorer in Land Desktop, they are drawn as AutoCAD 3D polylines in Civil 3D.

We should take a moment to talk about an exception to this rule: *Proximity breaklines*. Proximity breaklines are still around in Civil 3D, though we wish they weren't. The Proximity breakline is the only breakline that can accept a 2D polyline without elevation as its source. The problem with Proximity breaklines is most people don't really understand how they work. A Proximity breakline is not really a breakline by *polyline;* it's a breakline by *points*. When you select a polyline for definition as a Proximity breakline, the program (either Civil 3D or Land Desktop) searches for the nearest available point *selected in the surface* to each vertex of the polyline. If there's a real good match to points selected for the surface at every vertex of the polyline a Proximity breakline works great. Unfortunately, either many of the points in the drawing aren't selected for the TIN, or there isn't a good corresponding point for each vertex of the polyline, and the breakline just doesn't work well. We've had this discussion many times in the past twenty some years, but Proximity breaklines are not the panacea they appear to be. It's much better to construct 3D polyline breaklines or convert figures to breaklines directly.

Point Data Requirements

For use in creating connect-the-dot 3D polyline breaklines the points need to be displayed in the drawing at their actual elevation. This is a matter of displaying them through one or more Point Groups where Point Group Overrides specify a Point Style configured to display the Point Display Mode as **Use Point Elevation**, described in detail in Chapter 1211. The Bottom of Bank, Centerline, Edge of Pavement and Shoulder Point Groups in the Existing Base drawing all use the 0.05 X 3D point style, as shown by the tooltip by hovering over the group name in the Prospector as seen in Figure 1.87

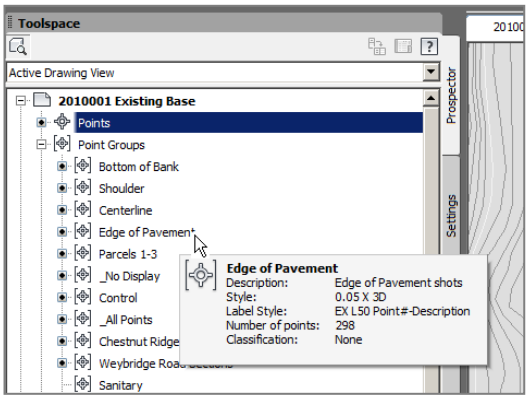


Figure 1.87 - Tooltip Showing Point Style

The tooltip doesn't tell you that a Point Style Override is in place to suppress the Description Key Style for each group, but it is.

An easy way to see the difference in point display modes is to rock the drawing up on its edge. While this can be accomplished a number of ways, we're going to go old-school again here: type **DDVPoint** at the command line and press **Enter**.

DDVPoint, which stands for *Dynamic Dialog View Point*, is a fast way to reset the point from which a drawing is viewed, without the vertigo that can accompany the Orbit, Steering Wheel or ViewCube.

Plus we tend not to use commands that weren't in AutoCAD 11 - just look at our screen for heaven's sake.

In the *Viewpoint Presets* dialog, click in the 10° position above the horizontal in the half wheel on the right - this will instruct AutoCAD to look down on the drawing from 10° above the XY plane. Press **OK**.

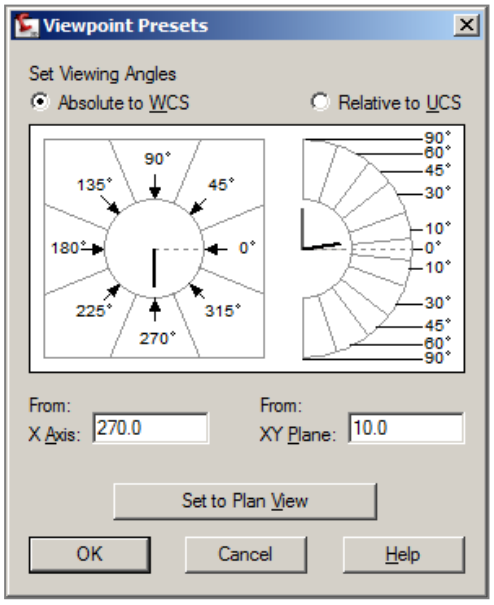


Figure 1.88 - DDVPoint Dialog

Looking at the drawing in 3D, one can see how the road section points are floating up in 3D space with the contours; they are the 3D data in the drawing at the moment. The parcel points are down in 2D space at elevation 0 in the drawing, with the road, buildings and water features.

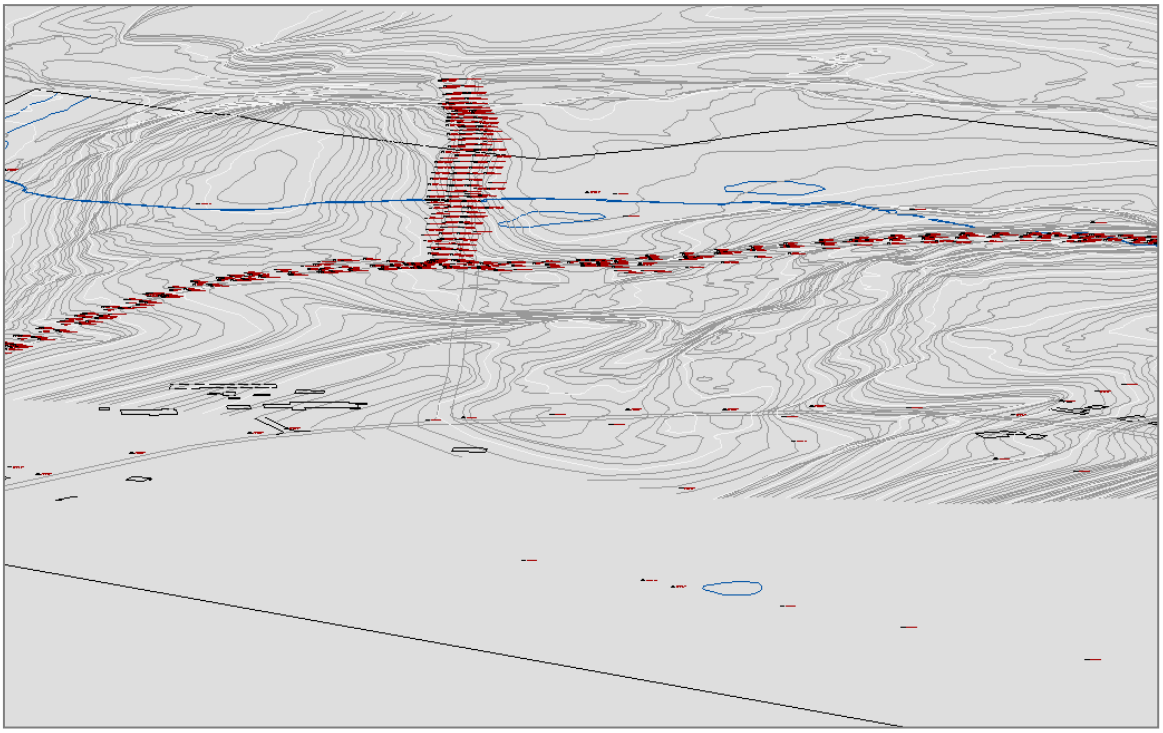


Figure 1.89 - Drawing Viewed in 3D

A 3D view like this is excellent for evaluating data which should have elevation values, and for checking work while drawing in 3D. In actual fact, the production of the 3D polyline breaklines runs a risk of missing a snap and accidentally dropping polyline vertex down to elevation 0, and that would be immediately detected in the 3D view. The problem is that it's pretty difficult to work in a 3D view like this, but AutoCAD can simultaneously display multiple docked viewports in Model Space - we just don't tend to do that much in Civil drawings.

Layer Considerations

Producing the breaklines will necessitate drawing 3D polylines; the polylines should be on their own layer. Again, there is a significant difference from Land Desktop here, as these polylines must remain in the drawing since there is no breakline database in Civil 3D: the breaklines in the surface are dynamically linked to the polylines in the drawing. Create a layer for the breaklines and make it current; we've used V-TOPO-BRKL-ROADS here.

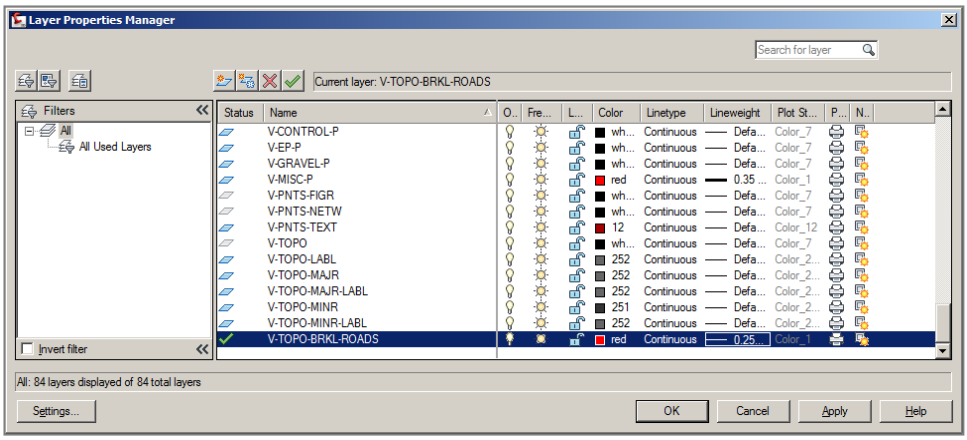


Figure 1.90 - Breakline Layer in Layer Properties

Isolating the Display of Points for Breaklines

3D polyline breaklines need to be drawn through the centerline points, edge of pavement points, shoulder points and bottom of bank points, working with each individual set in turn. It will be a lot easier to isolate the display of one set of data at a time to work with, and there are a couple of options available at the moment.

One option would be to use the *Point Group Display Order* set in *Point Group Properties* as described earlier. Shuffling the Edge of Pavement, Shoulder and Bottom of Bank groups below _No Display as seen in Figure 1.91 will work just fine.

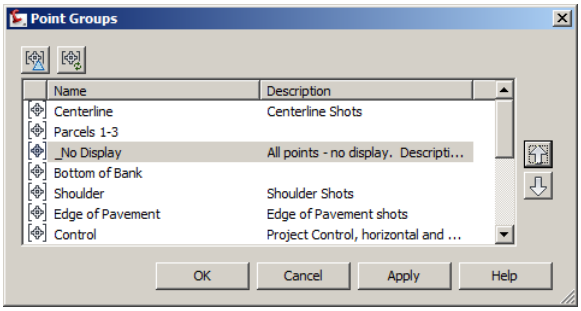


Figure 1.91- Point Group Display Order

The other option is to use layer management.

The Description Keys in use in this drawing did a very good job of routing the points that matched to their own individual layers. As we said previously, relying on layer management as the *sole* method to suppress point display is not a good idea, but it will work just fine for *temporary* display control. Knowing the layers used by the Description Keys obviously helps, but this can be a fast way to isolate the points we need.

In the *Layer Properties Manager* **FREEZE** the V-BOTBANK-P, V-EP-P and V-GRAVEL-P layers to isolate the centerline points. The layers must be ***frozen***; **OFFING** them will not work. Remember that Civil 3D objects have the same behavior as blocks, and you must freeze the layer of insertion to suppress the display of a block.

Remember that we're from Jersey, where "to off" is a verb. Interestingly, Spell Checker agreed.

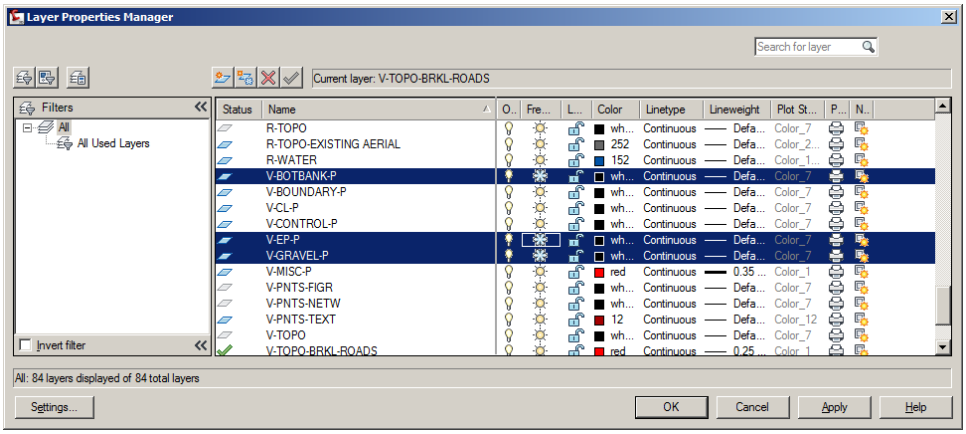


Figure 1.92 - Point Layers Frozen in Layer Properties

Drawing the Breaklines

Drawing the breaklines is another one of those refreshingly easy tasks in Civil 3D. Turn on a running **OSNAP** of **NODE**, take the phone off the hook, turn on some smooth jazz and type **3DPOLY** at the command line; it's literally just connect the dots from there.

If you do not normally use the middle mouse button for a *Pan* in AutoCAD, this is a good time to have it turned on temporarily with **MBUTTONPAN**; it's a lot easier to move along the points.

Don't be phased when the last segment you've drawn disappears as you Pan; it will come right back as you click on the next point.

Always keep an eye on the 3D viewport below; when you find yourself dropped down to 0 just use the `Undo` option in the command line and back up a vertex at a time until you're back where you belong. (You can also grip snap a vertex up to the node of a point if necessary.)

If you ignored our advice to take the phone off the hook you can **ENTER** out of the command and resume again later from the same point. There's no need to join the polylines, which isn't easy to do with a 3D polyline anyway.

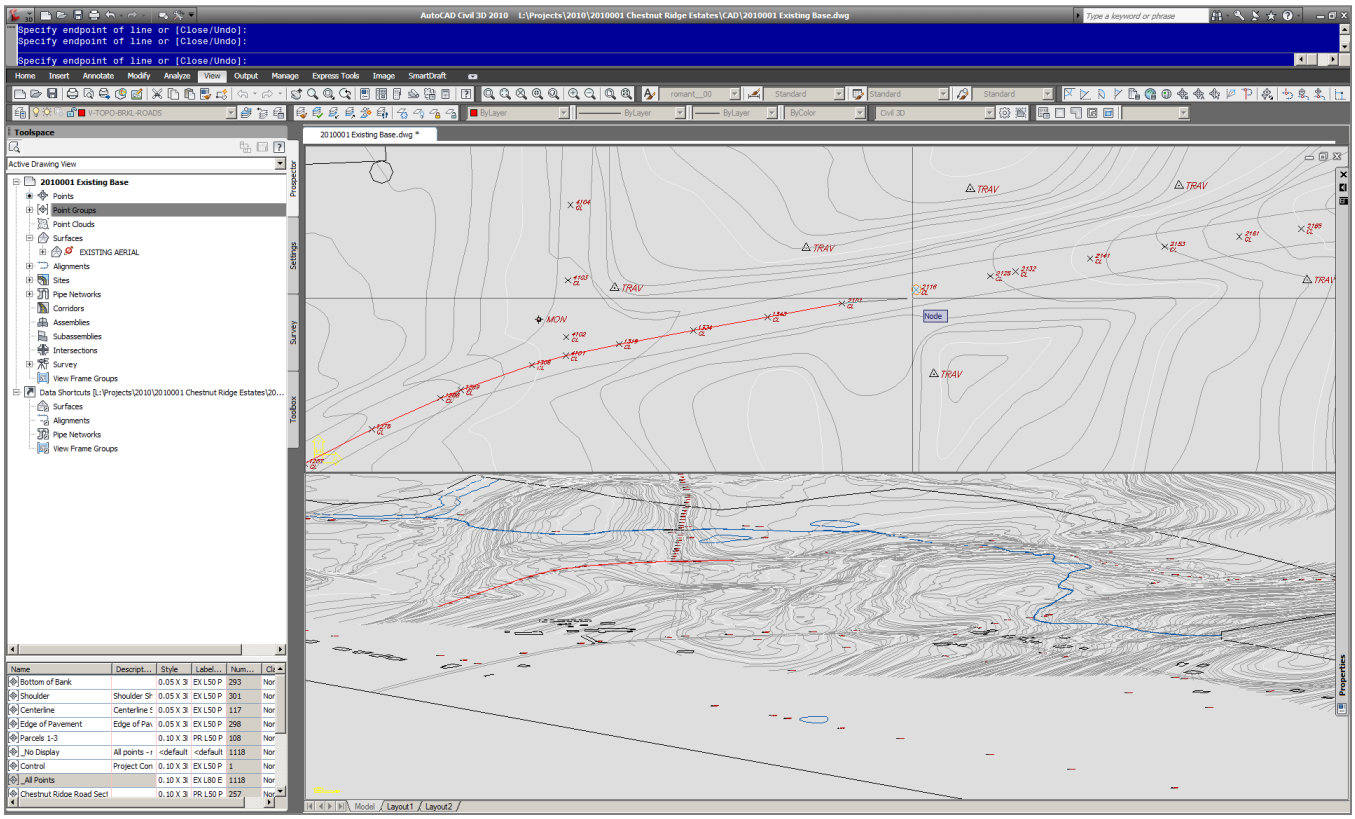


Figure 1.93 - Drawing 3D Polylines for Breaklines

When the centerlines are done, **FREEZE** their layer and **THAW** the next one, continuing on until all breaklines are drawn.

Using Field Generated Linework for Breaklines

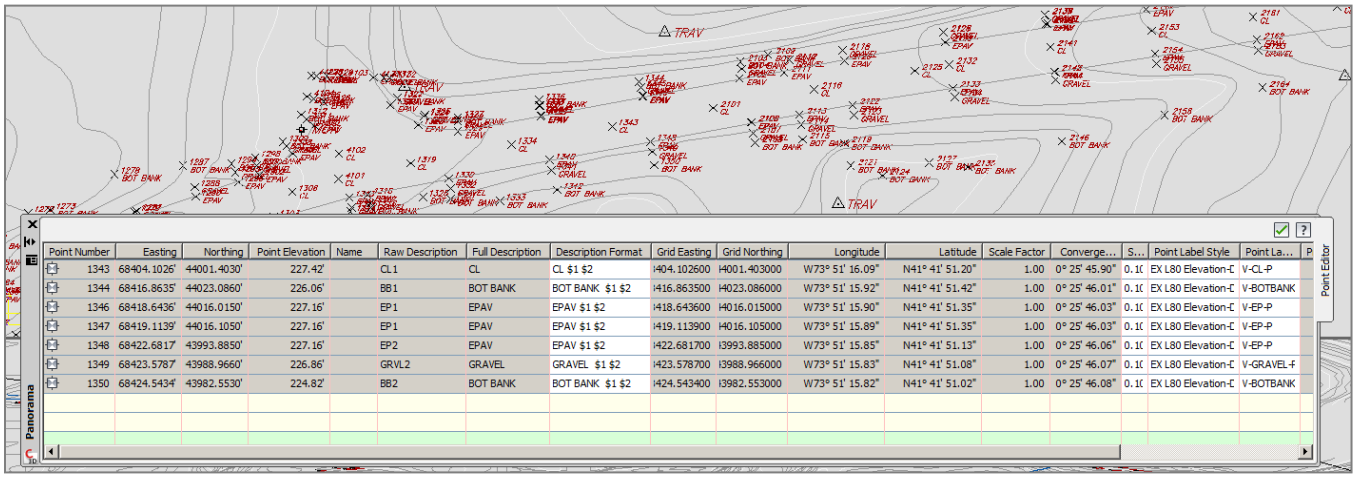
As we said earlier, there are a lot of options for creating breaklines besides connect-the-dots in the office; by far the best way is to have the field crews create them through linework codes. Civil 3D offers linework capabilities through the Survey side of the program, and additional Field-to-Finish capabilities are available from Carlson.

Another example of breakline creation field coding is the PConnect program offered by SmartDraft, a company producing add-on programs for Civil 3D. Information about PConnect and SmartDraft is available at www.smartdraft.com.

Like most other field coding methods mentioned, PConnect uses line numbers and codes easily added to point descriptions in the field, and readily editable in civil 3D in the office. Additionally, PConnect has the advantage of being fully compatible with the replaceable attributes on Civil 3D point descriptions.

The points shot for the road cross sections have linework codes that will support creating breaklines. A single cross section's worth of points is shown in the Point Editor in Figure 1.94 - notice the numbers following the CL, EP, GRVL and BB descriptions. PConnect will look for matching raw descriptions on the points, and will connect them in increasing point number order.

Our objective is not really to sell SmartDraft here, but we really do think this is a superior solution for field generation of breaklines. We'll examine PConnect in more detail in a Field-To-Finish chapter later, but right now it's going to save us from a lot of manual connect-the-dots.



Point Number	Easting	Northing	Point Elevation	Name	Raw Description	Full Description	Description Format	Grid Easting	Grid Northing	Longitude	Latitude	Scale Factor	Converge...	S...	Point Label Style	Point La...	P
1343	68404.1026'	44001.4030'	227.42'		CL1	CL	CL $1 $2	404.102600	4001.403000	W73° 51' 16.09"	N41° 41' 51.20"	1.00	0° 25' 45.90"	0.1	EX L80 Elevation-E	V-CL-P	
1344	68416.8635'	44023.0860'	226.06'		BB1	BOT BANK	BOT BANK $1 $2	416.863500	4023.086000	W73° 51' 15.92"	N41° 41' 51.42"	1.00	0° 25' 46.01"	0.1	EX L80 Elevation-E	V-BOTBANK	
1346	68418.6436'	44016.0150'	227.16'		EP1	EPAV	EPAV $1 $2	418.643600	4016.015000	W73° 51' 15.90"	N41° 41' 51.35"	1.00	0° 25' 46.03"	0.1	EX L80 Elevation-E	V-EP-P	
1347	68419.1139'	44016.1050'	227.16'		EP1	EPAV	EPAV $1 $2	419.113900	4016.105000	W73° 51' 15.89"	N41° 41' 51.35"	1.00	0° 25' 46.03"	0.1	EX L80 Elevation-E	V-EP-P	
1348	68422.6817'	43993.8850'	227.16'		EP2	EPAV	EPAV $1 $2	422.681700	3993.885000	W73° 51' 15.85"	N41° 41' 51.13"	1.00	0° 25' 46.06"	0.1	EX L80 Elevation-E	V-EP-P	
1349	68423.5787'	43988.9660'	226.86'		GRVL2	GRAVEL	GRAVEL $1 $2	423.578700	3988.966000	W73° 51' 15.83"	N41° 41' 51.08"	1.00	0° 25' 46.07"	0.1	EX L80 Elevation-E	V-GRAVEL-F	
1350	68424.5434'	43982.5530'	224.82'		BB2	BOT BANK	BOT BANK $1 $2	424.543400	3982.553000	W73° 51' 15.82"	N41° 41' 51.02"	1.00	0° 25' 46.08"	0.1	EX L80 Elevation-E	V-BOTBANK	

Figure 1.94 - Point Raw Descriptions with Linework Codes

The **PCONNECT** command can be picked from the **SMARTDRAFT** tab in the Civil 3D ribbon if loaded, and the dialog in Figure 1.14 displays.

The library of descriptions has already been created in SmartDraft, and it is a simple matter of selecting the **DESCRIPTIONS KEYS** to use, toggling on the **3D POLYLINES** option and pressing **OK**.

There are a number of other options in PConnect, including the source, the ability to read from a Survey Database, creation of both 2D and 3D polylines, and interpolation of vertices along breaklines and more.

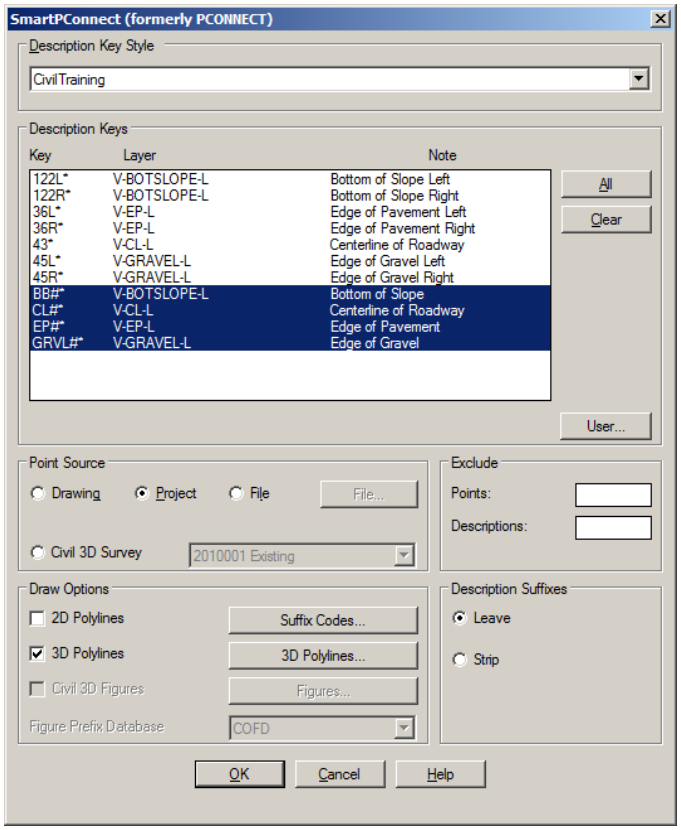


Figure 1.95 - PConnect Options

Created either manually or through SmartDraft, the resulting 3D polylines should look like this:

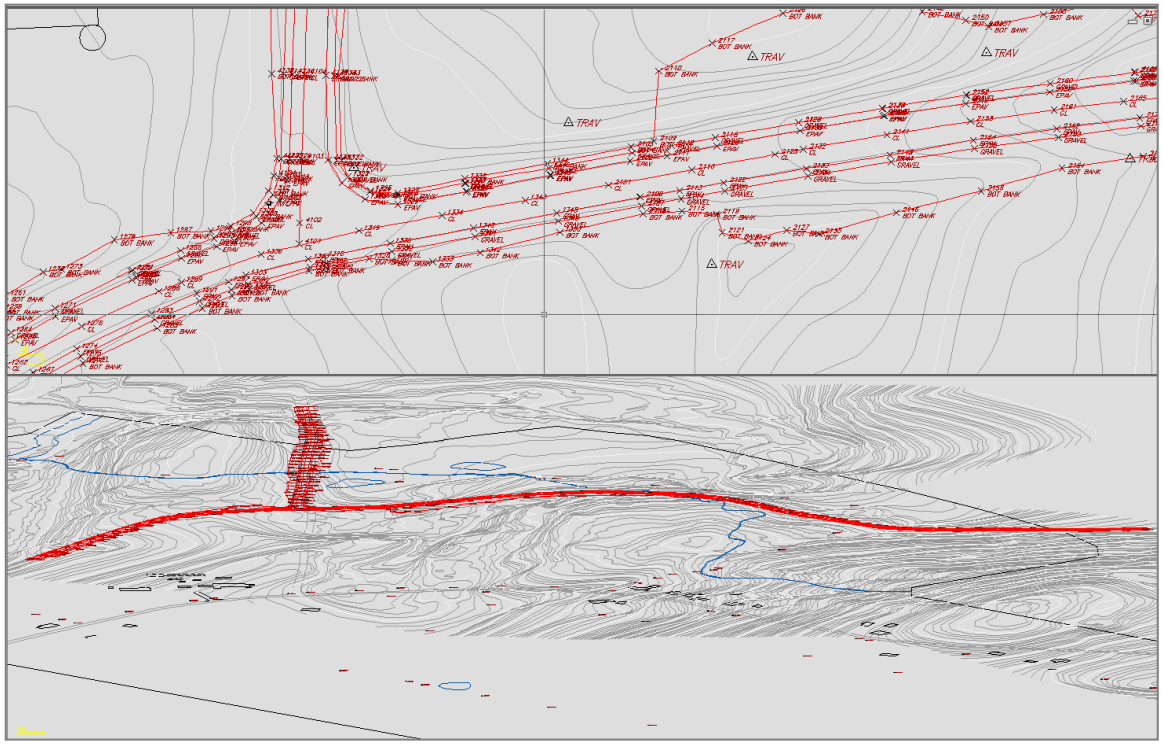


Figure 1.96 - 3D Polyline Breaklines

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Creating the Surface

With the breakline 3D polylines ready it's time to start the surface.

Return to a single viewport by typing **VPORTS** and picking **SINGLE** from the dialog.

RIGHT-CLICK on **SURFACES** in the **PROSPECTOR**, and click **CREATE SURFACE** from the menu.

The base **SURFACE LAYER** of C-TOPO will need to be overridden again for this survey surface; override the layer to V-TOPO as described in Chapter 1111. The **NAME** can be entered as ROAD SECTIONS, along with an appropriate **DESCRIPTION**. The **STYLE** should be set to Triangles Only. Press **OK** to create the surface definition in the Prospector.

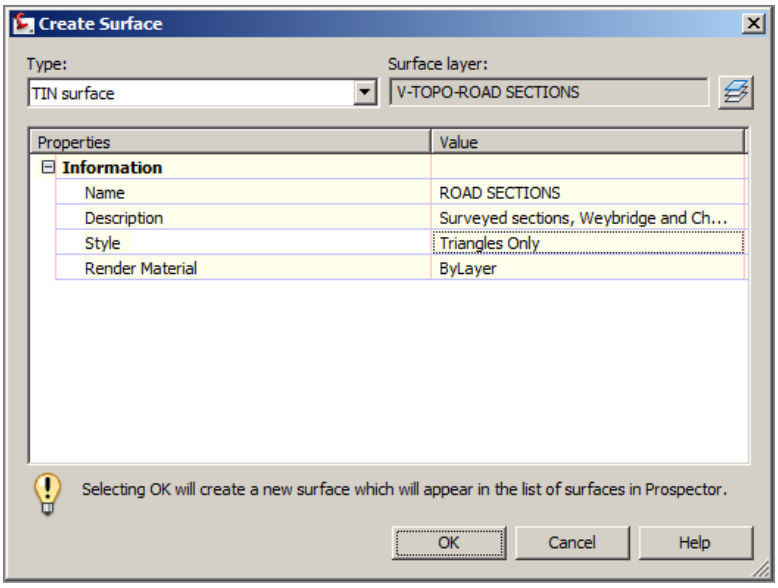

Figure 1.97 - Create Surface Dialog

Adding Breakline Data to the Surface

Expand the level below the ROAD SECTIONS surface in the Prospector, expand the **DEFINITION** level, and **RIGHT-CLICK** on **BREAKLINES**. Click **ADD** from the menu.

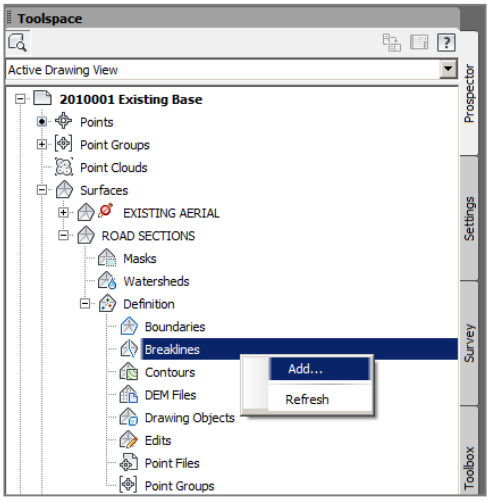

Figure 1.98 - Add Breaklines

In the *Add Breaklines* dialog enter a **DESCRIPTION** to identify the data.

Adding the Description is very important to identify the breakline data set in the overall surface data later, should it become necessary to adjust the surface build order.

The **TYPE** should be left at **STANDARD**, which is the selection method for 3D polylines.

The **WEEDING FACTORS** and **SUPPLEMENTING FACTORS** can be left **OFF**; these behave for breaklines exactly as described for Contour Data in Chapter 1111.

Press **OK**.

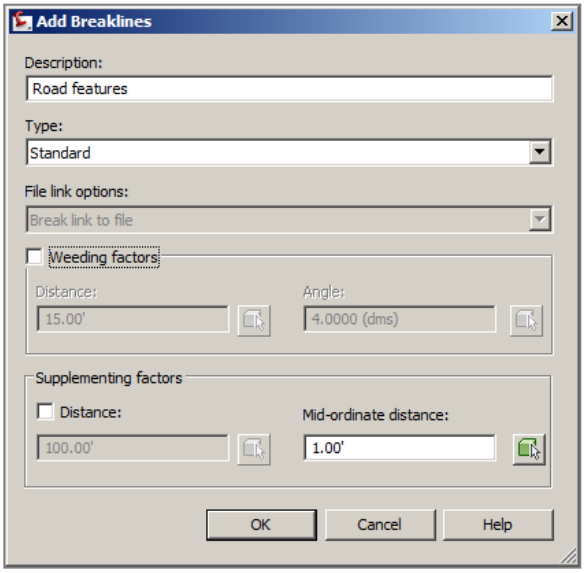

Figure 1.99 - Add Breaklines Dialog

At the `Select objects:` prompt the same layer hocus-pocus used previously will be repeated to temporarily isolate the 3D polylines:

At the `Select objects:` prompt type **'LA** and press **ENTER**; the *Layer Properties Manager* appears inside, and without interrupting, the AutoCAD selection. In the *Layer Properties Manager,* turn off all layers except the breakline layer - V-TOPO-BRKL-ROADS in this case. Press **OK** to exit the *Layer Properties Manager,* returning to the `Select objects:` prompt.

SELECT all of the breaklines with a **WINDOW** or **CROSSING** selection, ***but do not hit Enter to close the selection***.

AutoCAD is still at the `Select objects:` prompt; again type **'LA** and press **ENTER** to redisplay the *Layer Properties Manager*. Turn the layers back on (or restore a layer snapshot to be really tricky), and again press **OK** to exit the *Layer Properties Manager* and return to the `Select objects:` prompt.

At this point, the selection and layer hocus-pocus are done; press **ENTER** to end the selection, and Civil 3D adds the breaklines and rebuilds the surface.

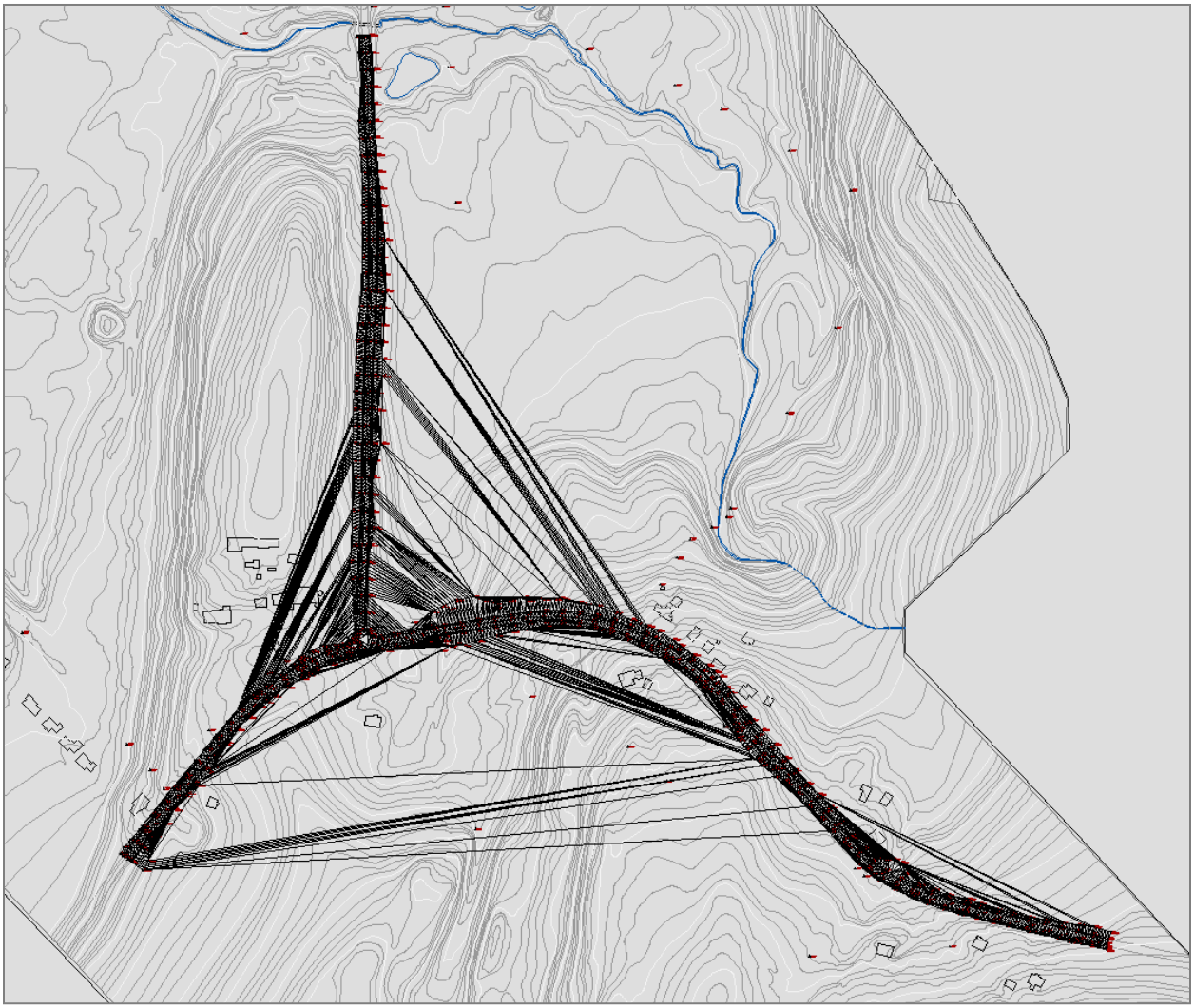

Figure 1.100 - Road Sections Surface As built to This Point

Adding Point Data to the Surface

The mechanism to add point data to the surface is the selection of one or more Point Groups; whether Civil 3D Points or Survey Points, points get added to the surface through Point Groups.

In this project there are two Point Groups that can be used in the surface, the Chestnut Ridge Road Sections and Weybridge Road Sections groups. Both of these groups contain points already used in the development of the breaklines, which will not cause any problems, as well as other desirable features picked up on the road surface. The ASCII files imported in this case were "clean", in that they did not include any shots on the tops of fire hydrants or the inverts of pipes in inlets, but a mechanism is needed to filter these shots out if they did exist. In any event, the two Point groups already created will suffice in this case.

To add these points **RIGHT-CLICK** on **POINT GROUPS** under the **DEFINITION** level below the ROAD SECTIONS surface in the **PROSPECTOR**, and click **ADD** from the menu.

In the *Point Groups* dialog **SELECT** the desired groups and press **OK**. The surface is rebuilt to include the points.

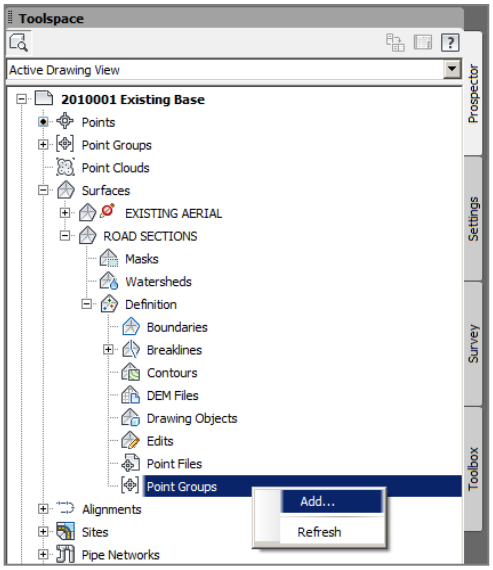

Figure 1.101 - Add Point Groups

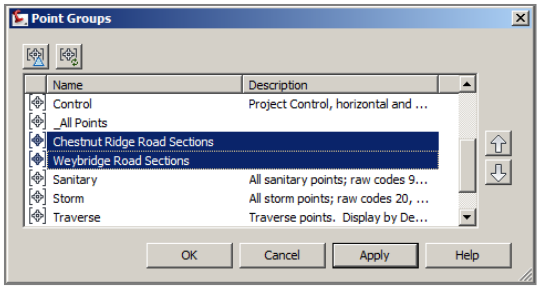

Figure 1.102 - Point Groups Dialog

Adding the Surface Boundary

To add the Boundary to the surface **RIGHT-CLICK** on **BOUNDARIES** below **DEFINITION** under the ROAD SECTIONS surface in the **PROSPECTOR,** and click **ADD** from the menu.

In the *Add Boundaries* dialog enter a **DESCRIPTION**. Set the **BOUNDARY TYPE** to **OUTER**. The option for **NON-DESTRUCTIVE BREAKLINE** can be **OFF**, as there is already a breakline in the same location. Press **OK**.

At the Select object: prompt **PICK** the Boundary polyline in the drawing. The boundary is added to the surface, and the surface is rebuilt. This cannot be seen, of course, as the layers are *off* and the surface style is _No Display.

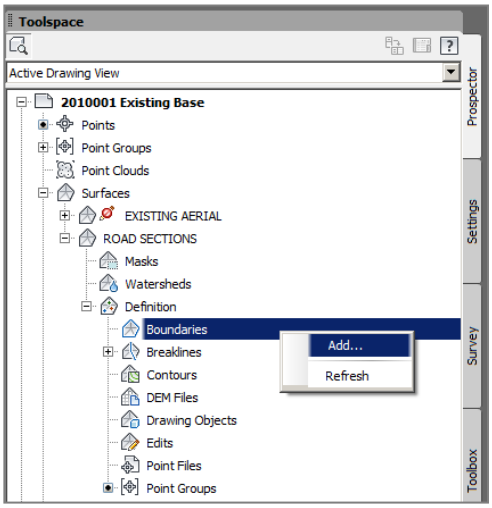

Figure 1.103 - Add Boundaries

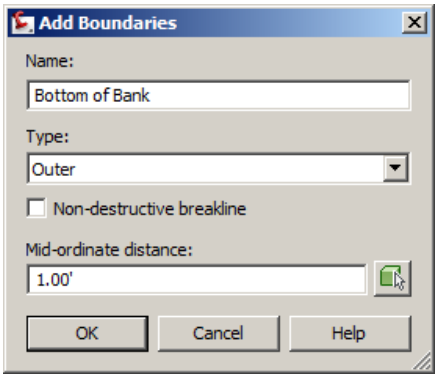

Figure 1.104 - Add Boundaries Dialog

Why the instructions to keep the boundary layer isolated and the surface out of view while adding the boundary? Every other time we've added data to a surface we've taken pains to be able to show you the result immediately… what's different?

When adding Boundaries to a surface Civil 3D seems to become "confused" when one object is directly on top of another. This "confusion" manifests itself in meaningless errors in th Event Viewer. If the other layers had been turned on and the surface displayed there would have been several objects present where the boundary was selected, the 2D polyline, the 3D polyline and a TIN line from the surface. Even with Display Order set correctly this would have resulted in "confusion". Isolating the layer and suppressing the surface display prevented the errors, and the appearance of the Event Viewer.

Restore the previous layer state, and change the **Surface Style** in **Surface Properties** back to _Triangles Only; the impact of the boundary should be immediately evident.

Save the drawing before continuing.

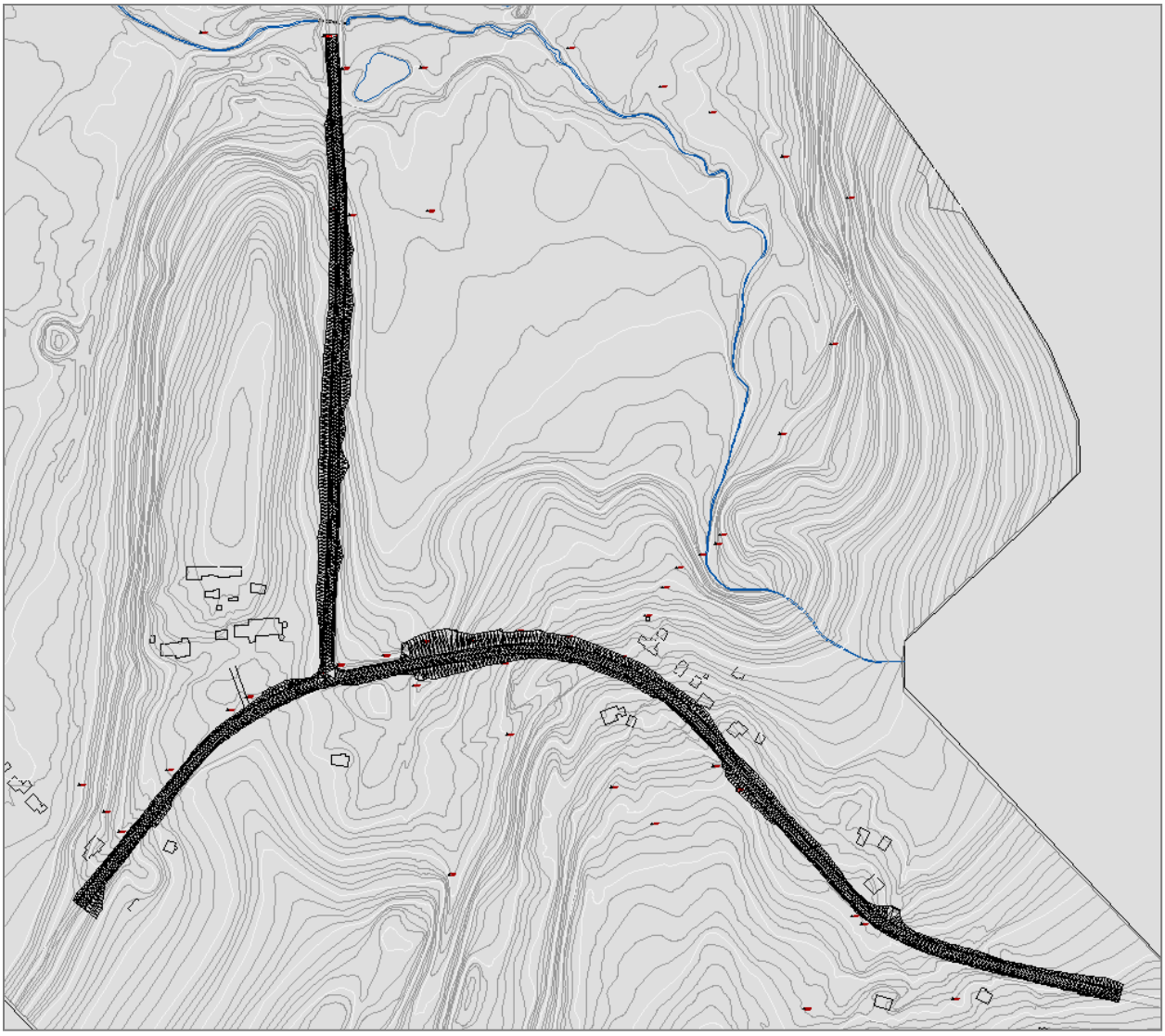

Figure 1.105 - Surface with Boundary Applied

Pasting Surfaces

Pasting or merging surfaces brings data from one smaller (child) surface into and replaces data in a larger (parent) surface. The procedure results in a combined surface, and is often used to combine grading with existing conditions, or higher accuracy existing with lower accuracy existing, as we will do here.

Many operators have difficulties with pasting surfaces, both in Civil 3D and in previous products. In order for one surface to be pasted into another the smaller child surface must have *logical connections* with the parent surface - it must actually meet the parent surface along its perimeter and cannot float above or below it. When one surface is pasted into another the process must be able to form reasonable TIN triangles between the two. These triangles cannot be vertical, as the TIN generator in Civil 3D cannot handle vertical faces. If the child surface sits above or below the parent to any significant degree vertical faces would be formed and the process will fail. What is a "significant

degree?" It's largely a matter of trial and error, but the better a child surface matches into the parent along its outer boundary the better it will paste.

Pasting Surfaces to Create the Existing Combined

The EXISTING AERIAL surface prepared earlier contained photogrammetric data along Weybridge and Chestnut Ridge roads. These data have now been supplemented with surveyed data in the form of the ROAD SECTIONS surface. In order to use the best available data for grading and all work that follows in the project the two surfaces need to be brought together to form one combined surface. While the road surface could be merged directly into the aerial, it's usually desirable to preserve the aerial surface as it was built. This leads to the creation of a third surface, EXISTING COMBINED, which begins as a copy of EXISTING AERIAL; the ROAD SECTIONS surface is then pasted into this third surface.

Copying the Aerial Surface

Copying a surface in Civil 3D actually takes place using a regular AutoCAD copy command, as the object being copied is a drawing entity. Some consideration needs to be made to the destination layer of the new surface, though, so a variation on the AutoCAD command will be used.

In order to be copied, the EXISTING AERIAL surface needs to be selectable, and it is present in the drawing in the _No Display style at the moment.

Use **SURFACE PROPERTIES** from the **PROSPECTOR** to change the **SURFACE STYLE** of the EXISTING AERIAL surface to Border Only. While you're there, change the **SURFACE STYLE** of the ROAD SECTIONS surface to _No Display.

The layers used for the boundary and breaklines for the ROAD SECTIONS surface are still displayed; **FREEZE** the V-TOPO-BNDY-ROADS and V-TOPO-BRKL-ROADS layers, setting any other layer current for the moment. Also freeze the R-BOUNDARY, R-CONTOURS-10 and R-CONTOURS-2 layers, which were the original aerial data.

Since we want the new surface created by this process to be on a new layer, execute the copy of the surface with the **COPYTOLAYER** command. This command can be found on the **CIVIL 3D** ribbon's **HOME** tab, **LAYER** panel, accessing the dropdown and picking the icon as shown in Figure 1.106.

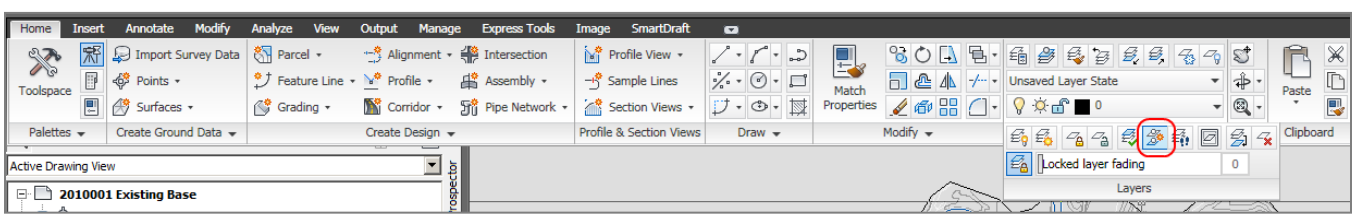

Figure 1.106 - Copytolayer in Ribbon

At the `Select objects to copy:` prompt **PICK** the EXISTING AERIAL surface border. Press **ENTER** to end the selection.

The *Copy to Layer* dialog displays. **TYPE** the new layer name in the top of the dialog as V-TOPO-EXISTING COMBINED and press **OK**. The *Create Layer?* dialog displays, press **YES**.

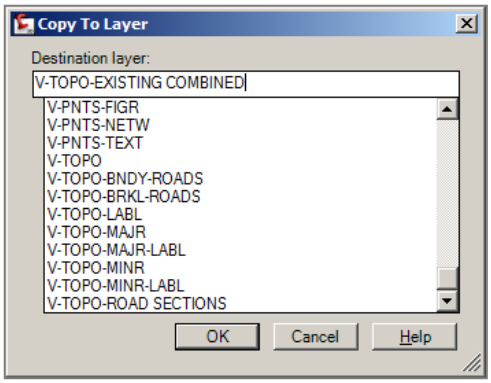

Figure 1.107- Copy to Layer Dialog

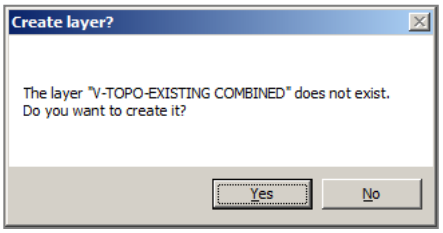

Figure 1.1086 - Create Layer? Dialog

There will be a noticeable pause as the surface is copied. When the prompt appears:

```
1 object(s) copied and placed on layer "V-TOPO-EXISTING COMBINED".
Specify base point or [Displacement/eXit] <eXit>:
```

Press **ENTER** to keep the copy in the same location as the original.

The new surface appears in the Prospector as EXISTING AERIAL (2), and is locked, as the original was locked when copied.

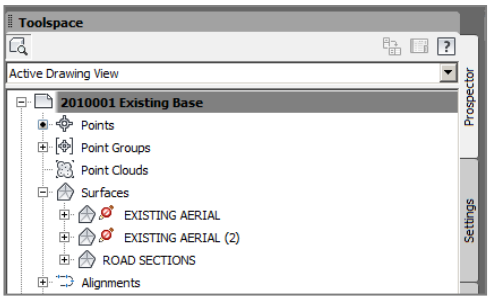

Figure 1.109 - New Surface in Prospector

At this point it is important to change the Surface style of the EXISTING AERIAL surface back to _No Display to prevent accidentally selecting it.

Several things need to be done with the new surface. **Right-click** on the EXISTING AERIAL (2) surface in the Prospector, and bring up **Surface Properties**.

Unlock the surface; it cannot be renamed until unlocked.

Change the surface **Name** to EXISTING COMBINED. Change the **Description** as appropriate.

Change the **Surface Style** to Triangles Only.

Press **OK**.

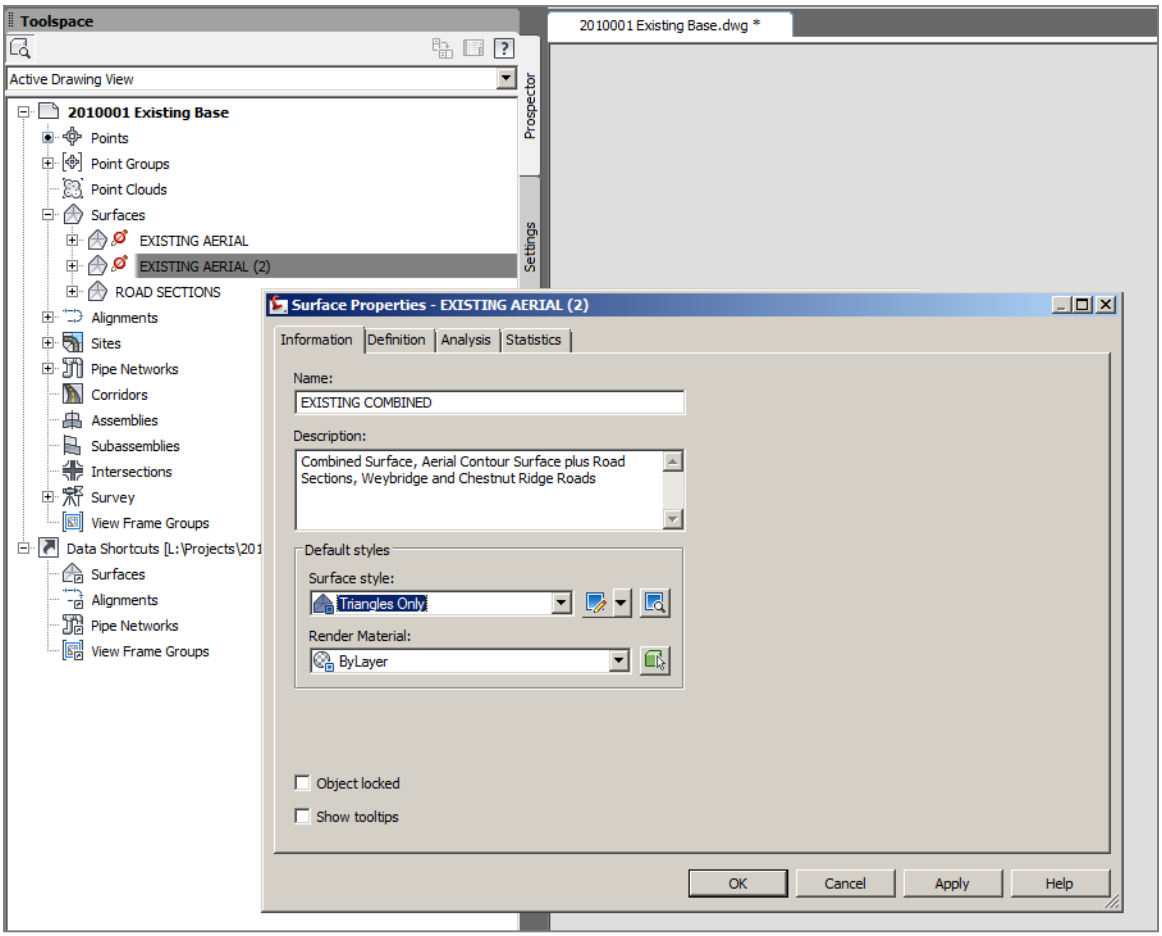

Figure 1.110 - Changes to Surface Properties for Existing Combined Surface

Zoom into the area of the intersection of the two roads in the drawing, and **Save** the drawing.

Pasting the Road Sections Surface

PICK the EXISTING COMBINED surface in the drawing to display its contextual Tab in the ribbon, or expand the **DEFINITION** level below its name in the **PROSPECTOR**. From either location, access **EDIT SURFACE/EDITS** as shown in Figure 1.111, and pick **PASTE SURFACE**.

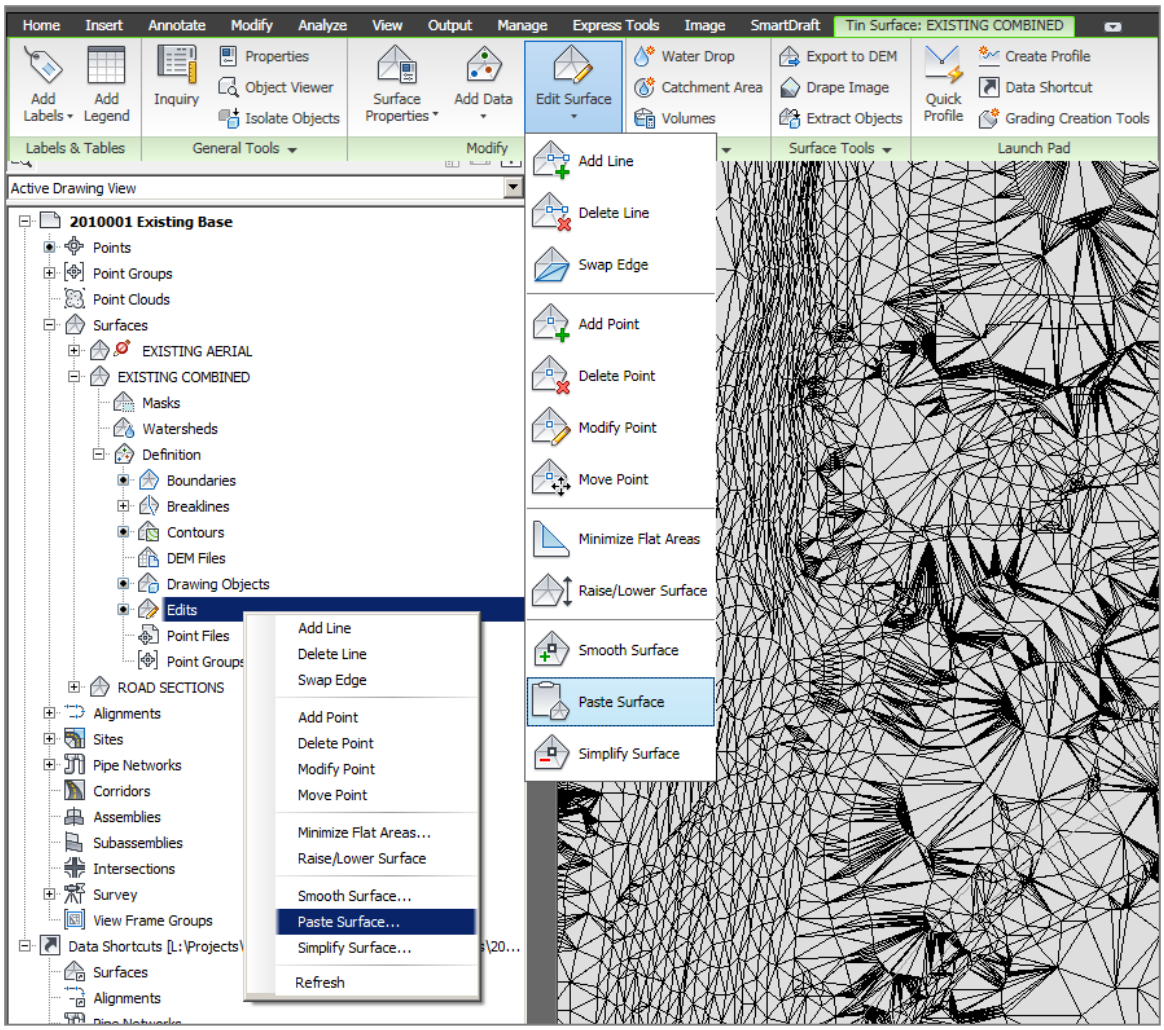

Figure 1.111 - Paste Surface in Prospector and Ribbon

The *Select Surface to Paste* dialog displays. **PICK** the ROAD SECTIONS surface and press **OK**.

The impact is immediate and dramatic.

SAVE the drawing.

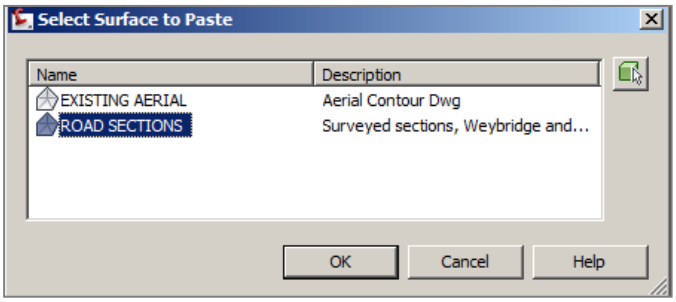

Figure 1.112 - Select Surface to Paste Dialog

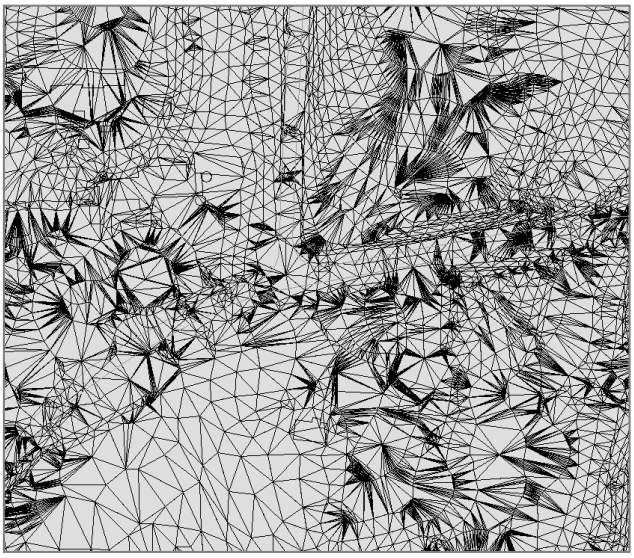

Figure 1.113 - Existing Combined Before Paste

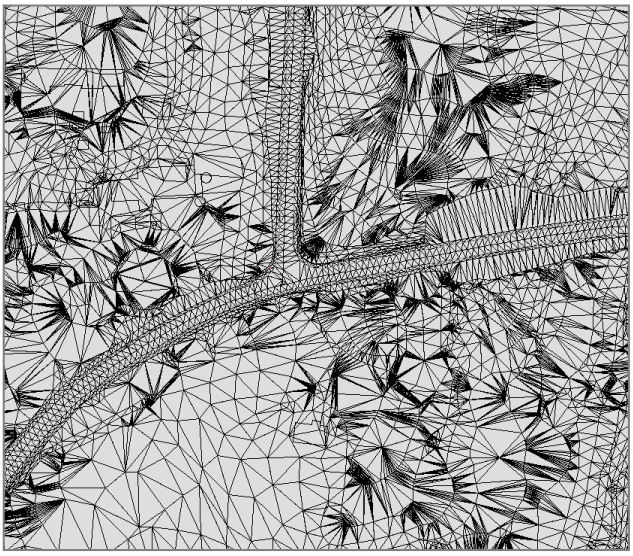

Figure 1.114 - Existing Combined After Paste

Surface Status Indications in the Prospector

As soon as the ROAD SECTIONS surface is pasted into the EXISTING COMBINED surface a new glyph appears on ROAD SECTIONS - a or Dependency glyph which means it is used somewhere else - in the EXISTING COMBINED surface.

At this time both the ROAD SECTIONS and EXISTING COMBINED surfaces are unlocked; surfaces should always be locked when not being edited. **RIGHT-CLICK** on each in the **PROSPECTOR**, and select **LOCK** from the menu.

The fact that the ROAD SECTIONS surface is combined into the EXISTING COMBINED surface, and both are locked, will eventually result in an annoying anomaly in Civil 3D; sooner or later a warning glyph - - is going to appear on one or both of the surfaces, trying to convince you that a *Rebuild* of the surface is needed. This will occur in spite of the fact that ***nothing has changed in the dat***a in either surface, and it points out something about glyphs in civil 3D - ***they sometimes lie***. A rebuild of the surfaces would not be necessary, and would be time consuming at best. It is important here to make sure that a rebuild does not occur automatically, and it's a good idea to make sure the **REBUILD AUTOMATIC** setting on surfaces is kept **OFF**, unchecked in the Prospector.

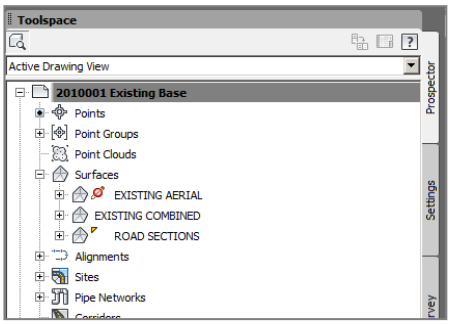

Figure 1.115 - Dependency Glyph

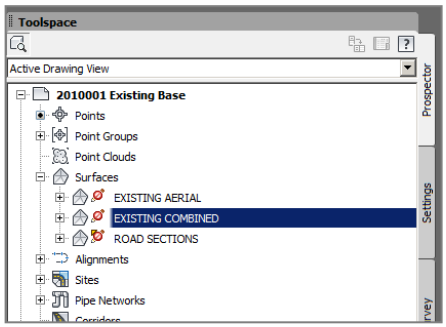

Figure 1.1163 - Surfaces Locked

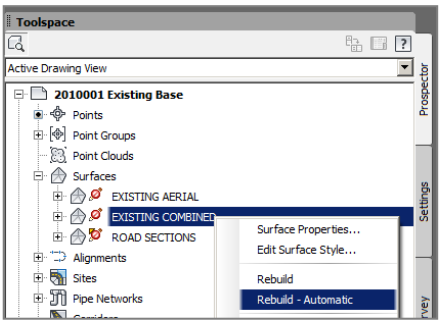

Figure 1.117 - Rebuild Automatic Off

Close-In Photogrammetry with Autodesk Recap 360

As an example of this application we took a series of photographs of several headwall structures, one of which is shown here.

Figure 1.115 – Headwall Structure Used for Recap 360 Test

The complete series of 50 photographs was uploaded to Autodesk Recap 360, an Autodesk subscription service which converts the photographs into 3D models in several formats, including Point Cloud and Mesh models. Part of the import process is seen in the illustration below, along with some of the various file formats that can be produced.

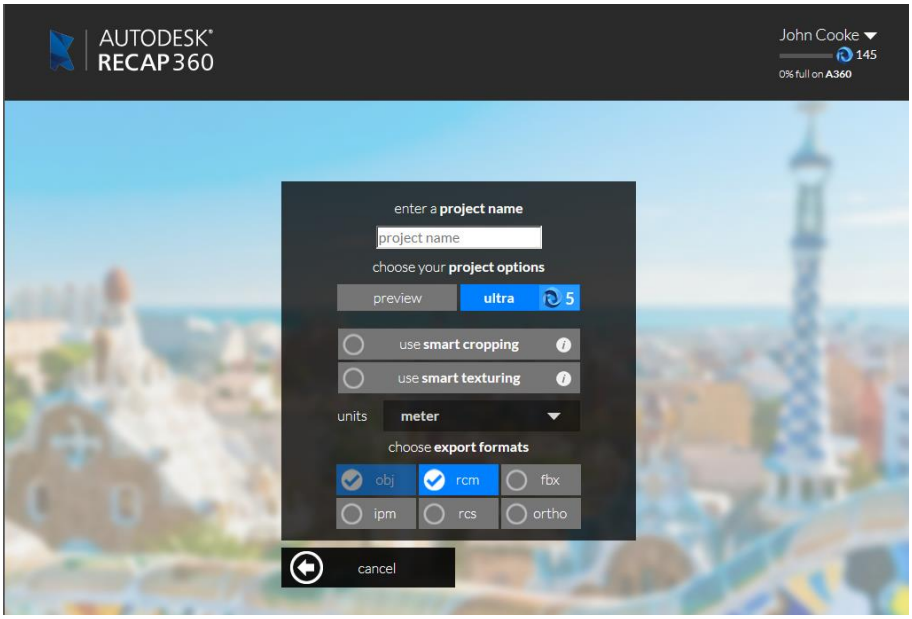

Figure 1.116 – Recap 360 Upload, Including File Formats

The initial objective in using recap 360 was to produce the Point Cloud, in the Autodesk .RCS file format. While the RCS model is of stunning quality when imported into AutoCAD, its viability for surface production directly in Civil 3D is somewhat limited. While the point cloud itself can be used to directly produce a surface, the amount of information contained exceeds the detail required in most applications. Snapping to the point cloud to draw traditional breaklines is difficult, if not impossible; though the point cloud can be snapped to with an AutoCAD node snap, it is virtually impossible to prevent snapping "though" the cloud to a vertex behind the desired feature.

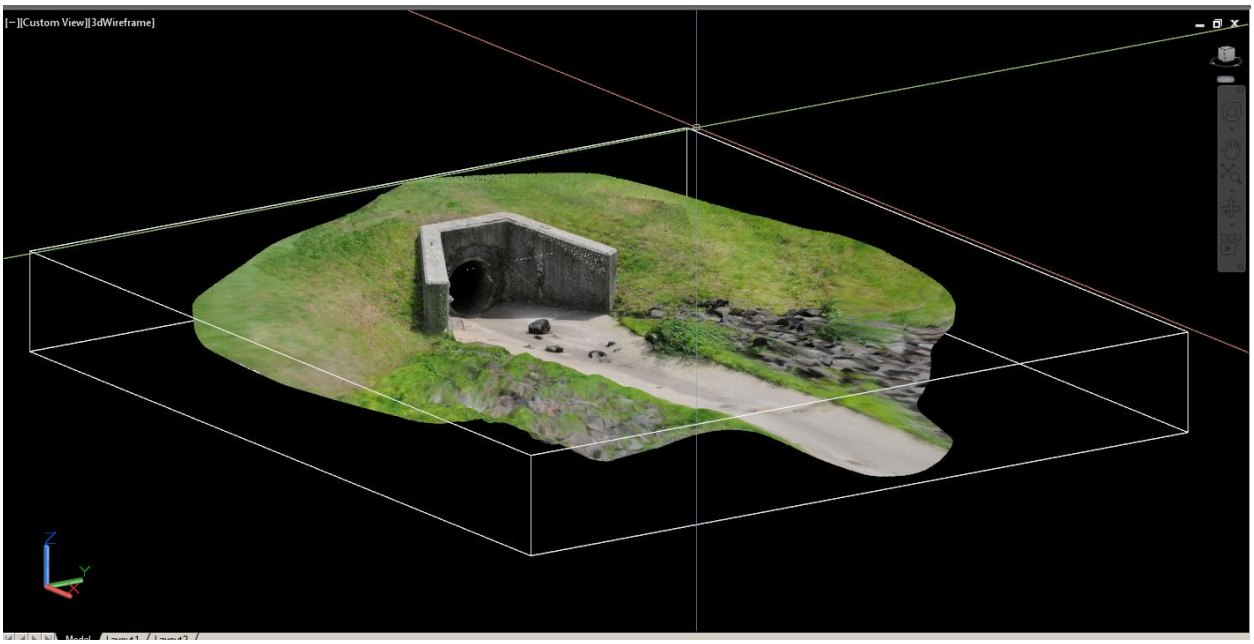

Figure 1.117 – Recap 360 Model as RCS Point Cloud Inserted in Civil 3D

An alternative method with greater usability is based on the creation of a OBJ mesh model in Recap 360. It should be noted that AutoCAD cannot directly import a .OBJ file, but can do so with an inexpensive plugin for AutoCAD from CodeDog (www.codedog.com.au).

The mesh model created by the OBJ file in AutoCAD is somewhat more forgiving and supports the creation of traditional breaklines as 3D Polylines, snapping to the vertices of the mesh with an Endpoint snap. Care must still be taken, however, to prevent snapping through model to vertices behind the desired faces.

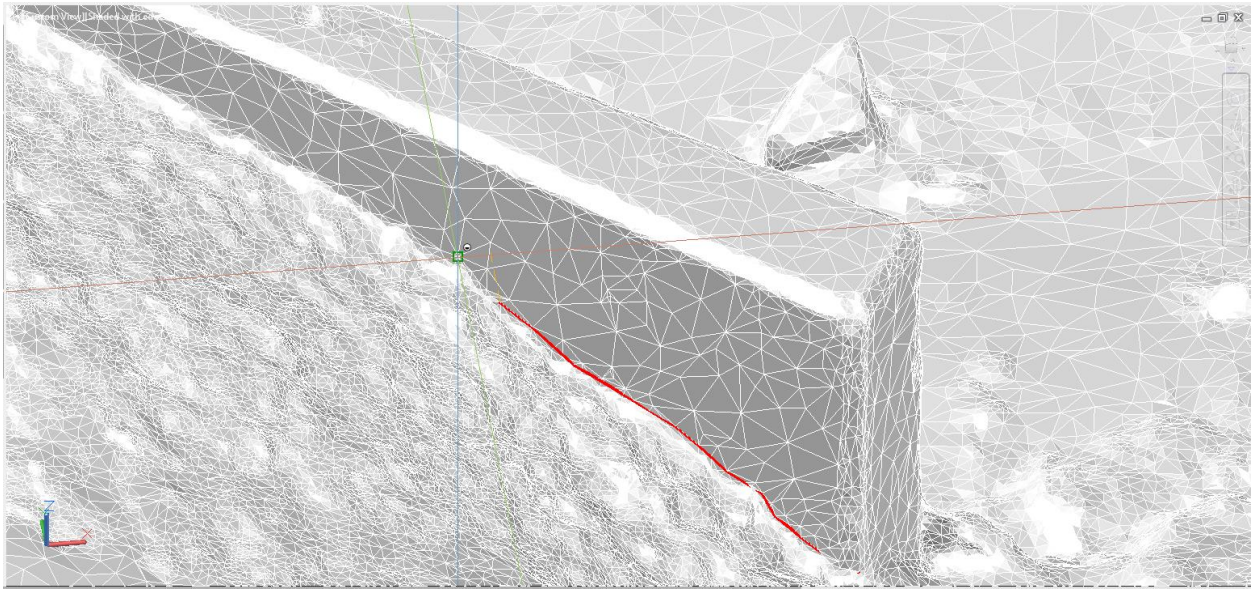

Figure 1.118 – Snapping to Vertices of 3D Mesh Model with 3D Polyline

Scanning Options with Entry Level Devices

The implementation of laser scanning within the Survey industry is constantly expanding, both in capabilities and in cost – both seem to be increasing exponentially. In this example, we focused on an entry level solution, with hardware and software costs within the reach of most smaller firms. Although larger firms seem to be able to spend almost limitless amounts of money, the hardware and software combination used here cost less than $75,000: a Leica Nova MS50 Multistation and Leica Infinity software.

For this example we deployed the Nova in less-than-optimal conditions typical of a site that would be difficult to survey traditionally – surveying a steep bank located across the Fishkill Creek in Beacon, NY on a chilly December morning. The scanner was working across a distance of approximately 150 feet adjacent to a waterfall, with significant spray as seen in the photo below.

Figure 1.119 – Nova MS50 Setup to Scan

The scanner was configured to scan a 0.05’ x 0.05’ grid, with the total scan taking 30 minutes to complete.

Samples of the scan data as displayed in Infinity are shown on the following page.

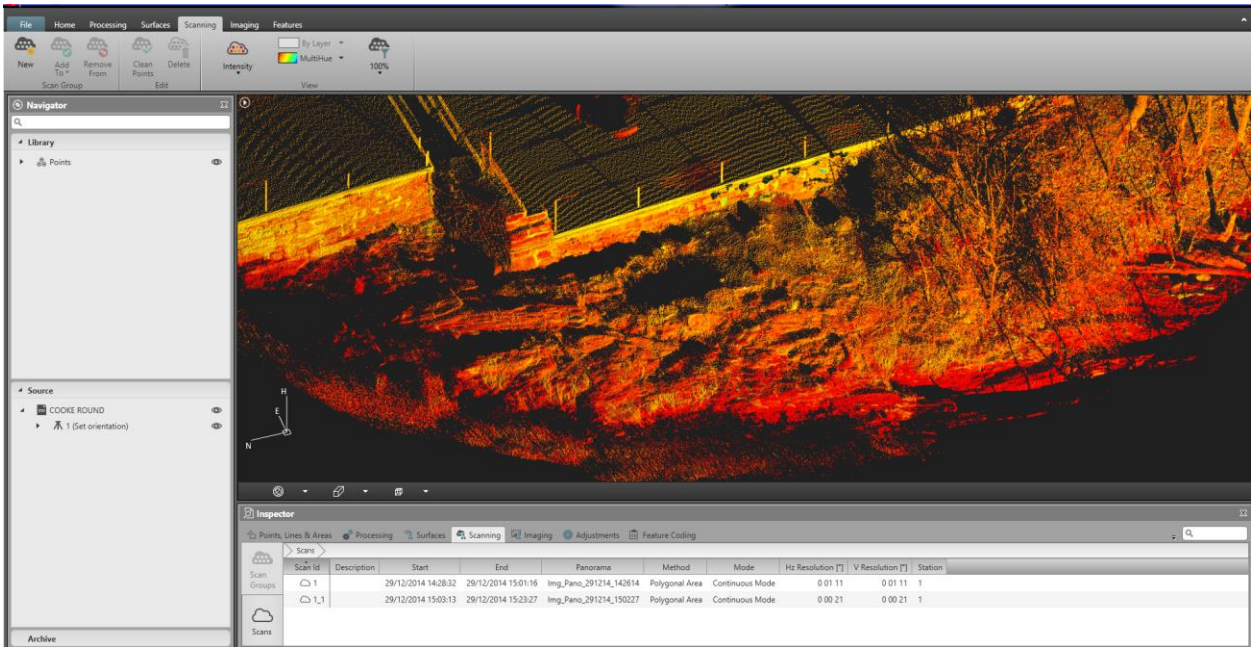

Figure 1.120 – Scan Data Displayed in Leica Infinity Software

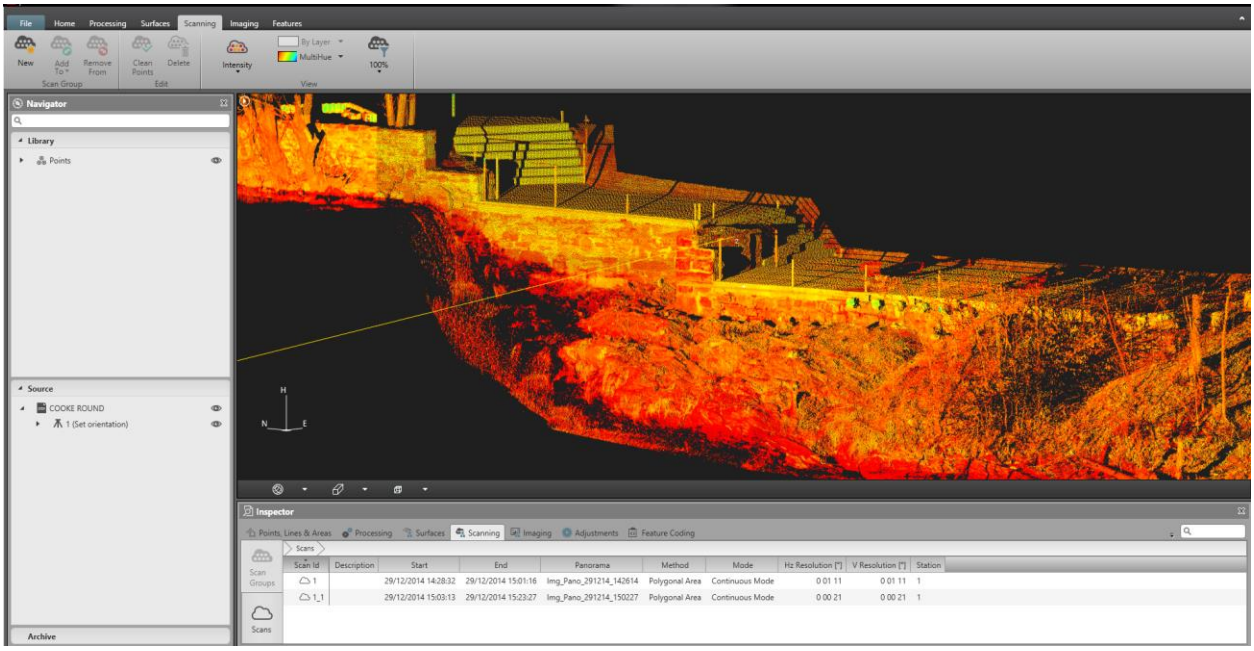

Figure 1.121 – Scan Data Displayed in Leica Infinity Software

After minimal editing of the point cloud in Infinity to remove the trees from the scan, Infinity is able to produce a TIN surface which can be exported to LandXML, and is readily imported by Civil 3D, Carlson, or other software packages.

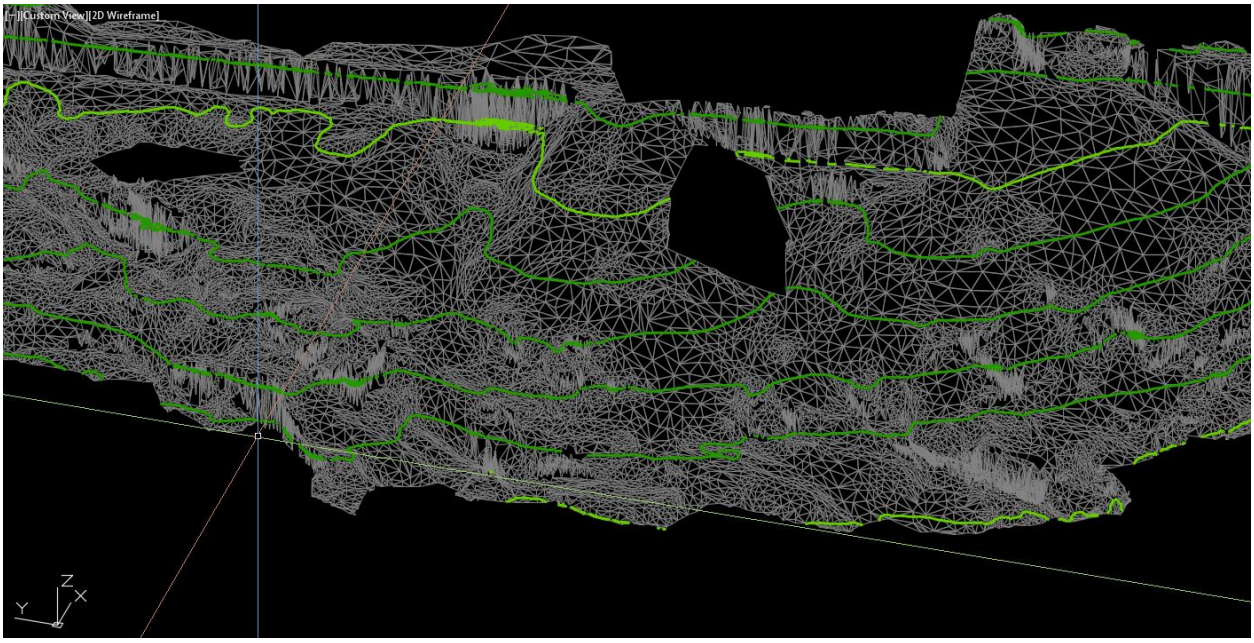

Figure 1.122 – Leica Infinity TIN Imported via LandXML in Civil 3D After Minimal Editing

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