Module 4

Vertical Alignment

April 11, 2023

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About this Practice Workbook...

- This PDF file includes bookmarks providing an overview of the document. Click on the bookmark to quickly jump to any section in the file. You may have to turn on the bookmark function in your PDF viewer, such as Adobe Reader.

- The dataset used throughout this module uses English units and US Survey Feet.

- Each module in this series is self-contained. You can jump to any module and begin the exercises.

- This training module uses the DOT-US North Carolina WorkSpace and the R-2635C (Training) Workset installed. It is very important that you select the correct WorkSpace, Workset and Desktop Icon/Discipline/future Role **NCDOT_Roadway** when working the exercises in this course.

- The tool tips and help were copied from the Bentley Online Help. See this link for the complete list of tools and common usage.

  OpenRoads Designer CONNECT Edition Help (bentley.com)

- This workbook was written with the release of OpenRoads Designer 10.09.00.91 (2020 Release 3 Update 9).

- This workbook has been updated for OpenRoads Designer 10.10.XX.XX (2021 Release 1 Update 10).

Table of Contents

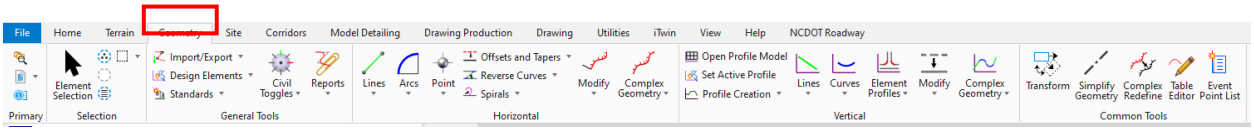
Overview

Vertical alignments are very different in ORD when compared to using Geopak. The vertical alignment in Geopak had no intelligence, when using Geopak the vertical alignment was only a station and elevation. This could be applied to any alignment as long as the alignment covered the station range.

When using ORD each vertical alignment will be associated with a horizontal alignment. Each horizontal alignment can be associated with multiple vertical alignments, but each vertical alignment can only be associated with a single horizontal alignment.

Designing and ORD vertical alignment is like designing an ORD horizontal alignment. There are rules and design intent that will build a level of intelligence into the vertical alignment.

Geometry Ribbon Tab

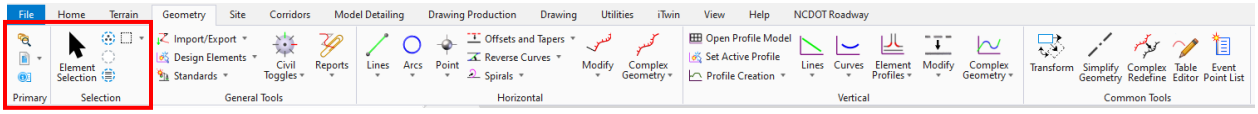


The *Geometry* Ribbon contains tools that the designer will use to create Horizontal and Vertical Geometry and plan elements that are based on Civil Geometry. The Ribbon is broken into 6 sections.

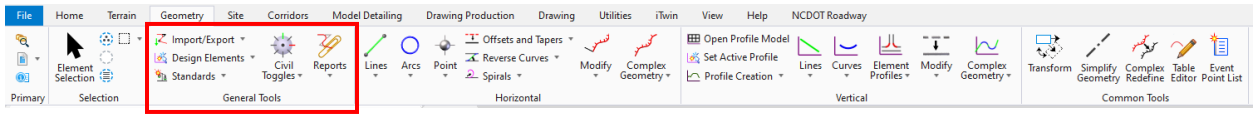
This section of the training Module will only focus on the tools used to create Vertical alignments. These tools will include Lines and Curves and will function very similar to the tools used for Horizontal Alignments

Primary & Selection Tool Group

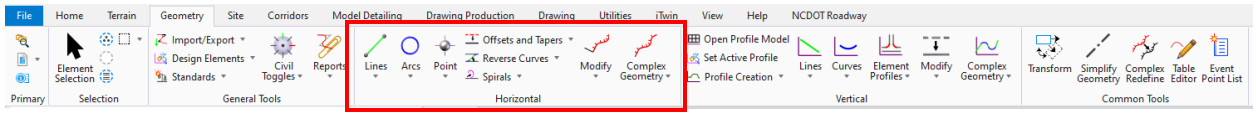
These two (2) groups are common throughout the ribbons. To see all the tools in these sections, use the Home Ribbon. The other Ribbons include a partial group of the tools included in these two sections



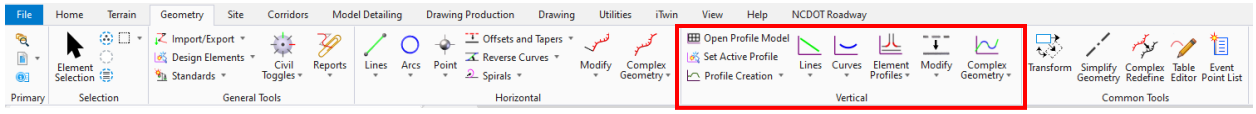
General Tool Group



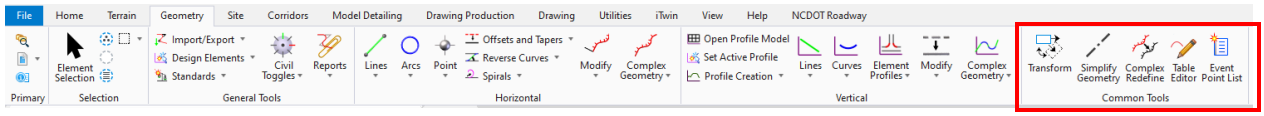
Horizontal Tool Group



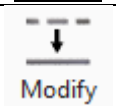
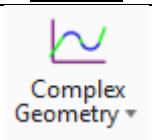
Vertical Tool Group



Common Tool Group



(Table 2-1) Important Tools Used in Vertical Alignments

 Lines	Various line placement tools (Between Points, To Elements, From Elements, Between Elements)
 Curves	Various curve placement tools (Between Points, To Elements, From Elements, Between Elements)
 Modify	Tools used to edit profiles, including inserting curves
 Complex Geometry	Creating and redefining Complex alignments, Best Fit, Offset tool (copy parallel) and reverse transitions.
 Table Editor	Tool used for editing profiles, generally used to edit VPI stations and elevations.

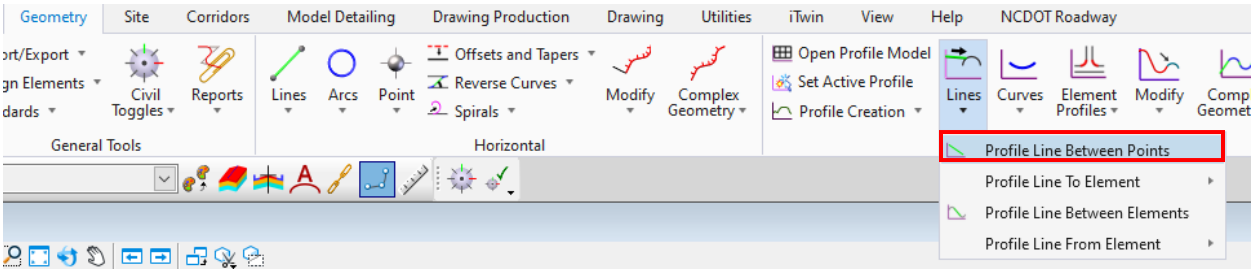
Feature Definition Toolbar

Feature Definitions are included in the NCDOT workspace. They are used to control symbology, and various other properties that are applied to the geometric elements. In the same way that using the correct feature definition for the horizontal alignment is an important part of the design process it is important to use the correct feature definition for the vertical alignment design process.

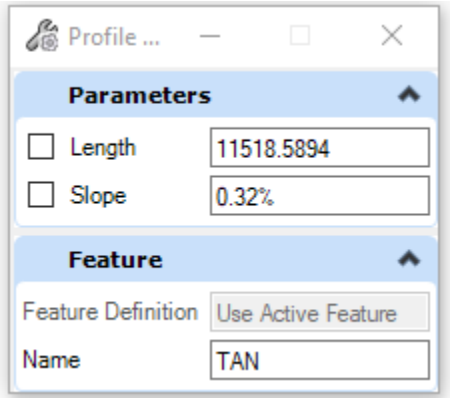
Vertical Geometry – Line Tools Overview

The vertical geometry Line tools are like the horizontal geometry line tools in for and function. The design parameters are all based on vertical attributes instead of horizontal, but the use of the tool should be familiar.

1. **Profile Line Between Points**
   A. **Profile Line Between Points** is one of the most basic tools that will be used during design and will draw a line between two user defined points.

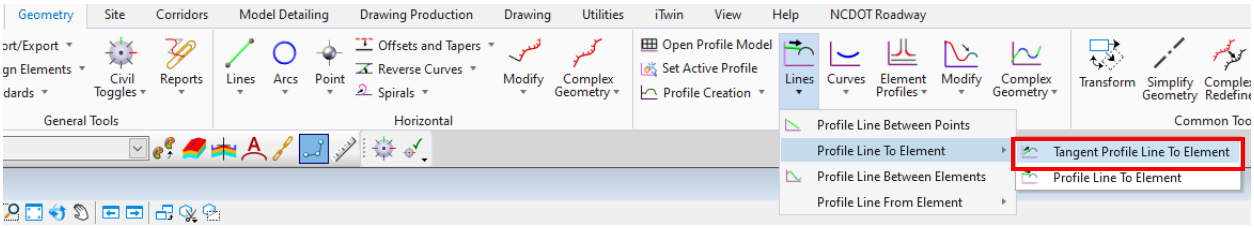


   B. The available dialog box will allow for direct input of slope and length.

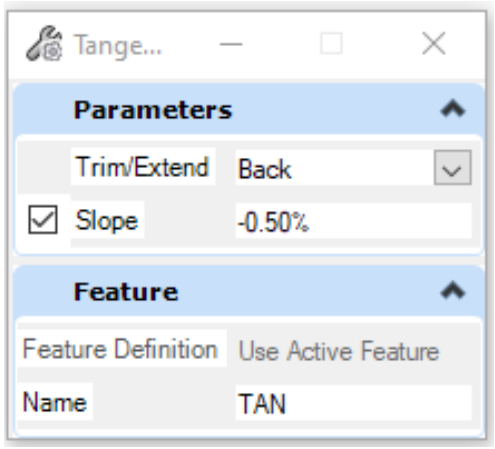


2. Tangent Profile Line to Element

A. The **Tangent Profile Line to Element** tool draws a line tangent to an element based on a user defined end point.

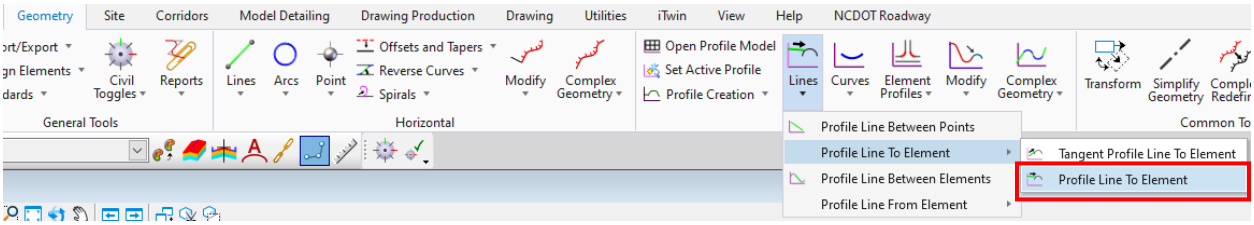


B. At the dialog prompt there is an option to enter and lock a slope. If a slope is selected the program will construct the line to the point on the To Element where that slope is tangent.

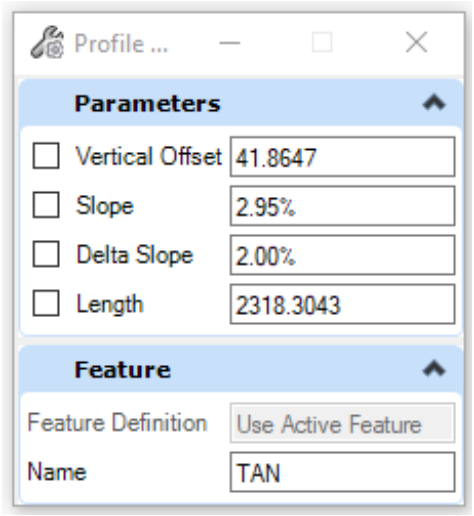


3. Profile Line to Element

A. The **Profile Line to Element** tool draws a line to an element based on a user defined end point.

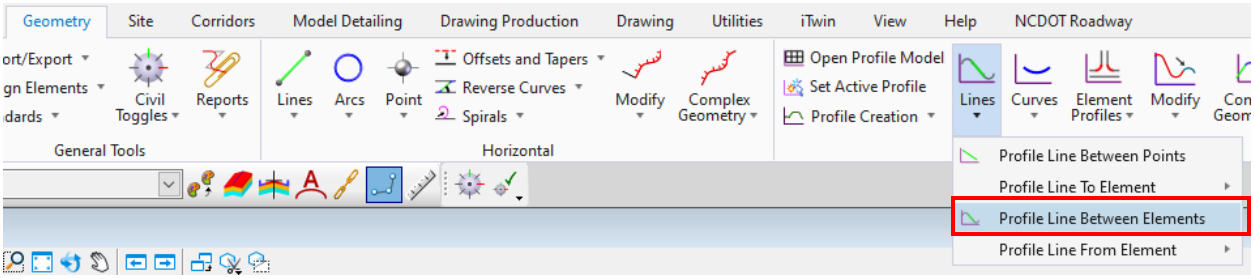


B. This tool has the added capability of applying an Offset from the To Element and Applying a grade break from the tangent slope at the To Element.

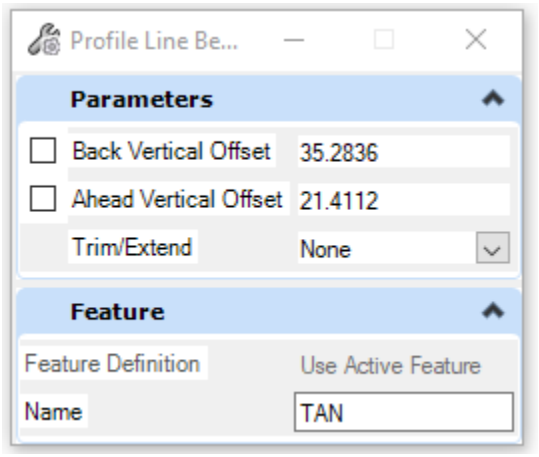


4. Profile Line Between Elements

A. The **Profile Line Between Elements** tool is used to construct a line between two previously placed curves.

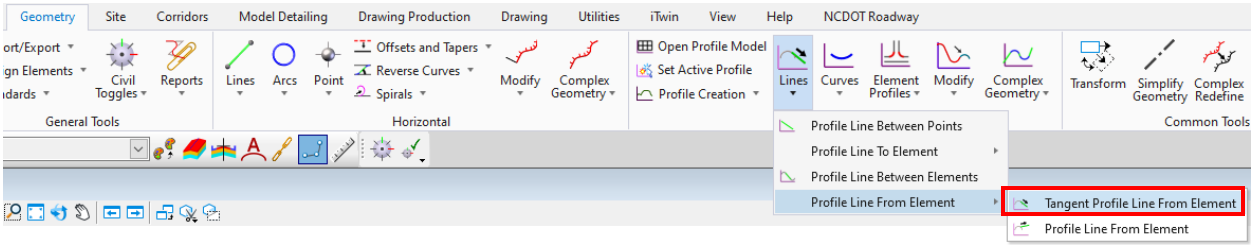


B. This tool will allow the user to specify offsets to the reference elements.



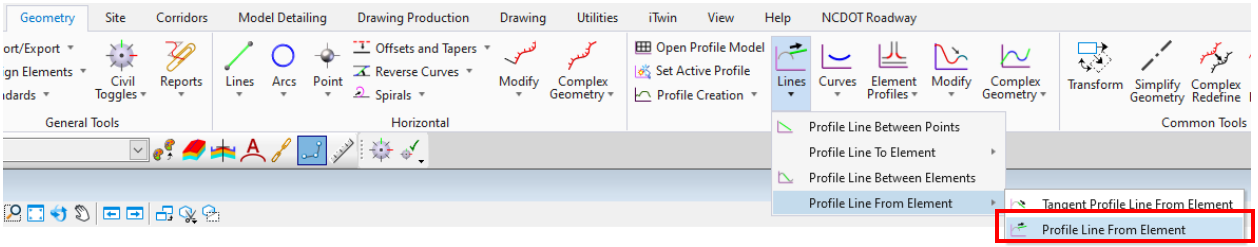
5. Tangent Profile Line From Element

A. The **Tangent Profile Line From Element** tool is like the To Element tool, but the line starting point is located on the From Element



6. Profile Line From Element

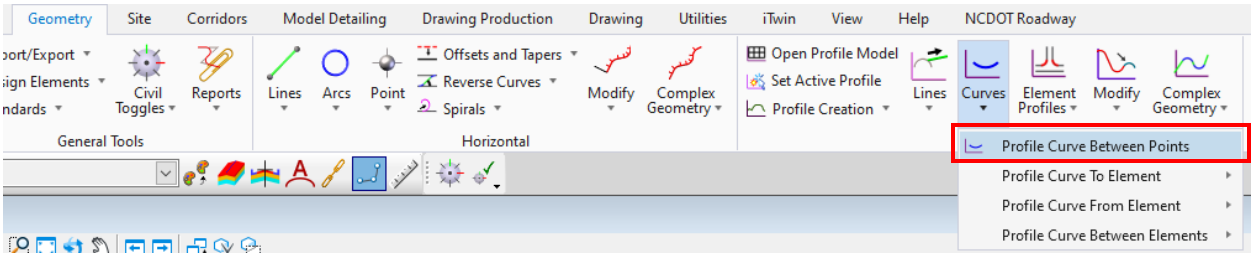
A. The **Profile Line From Element** tool is like the To Element tool, with the starting point located on the From Element and also allowing the user to apply an offset or a grade break.



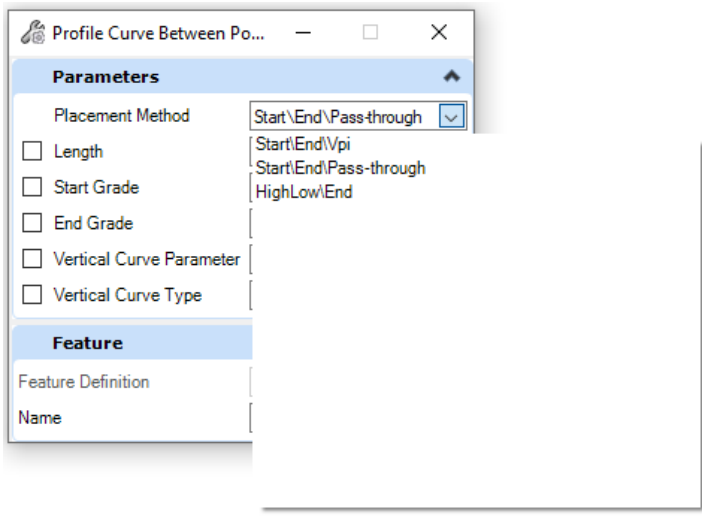
Vertical Geometry – Curve Tools Overview

The vertical geometry Curve tools are like the horizontal geometry curve tools while being much simpler to use. The design parameters are all based on vertical attributes instead of horizontal, but the use of the tool should be familiar.

1. **Profile Curve Between Points**
   A. **Profile Curve Between Points** allows the user to place a curve independent of any tangents.

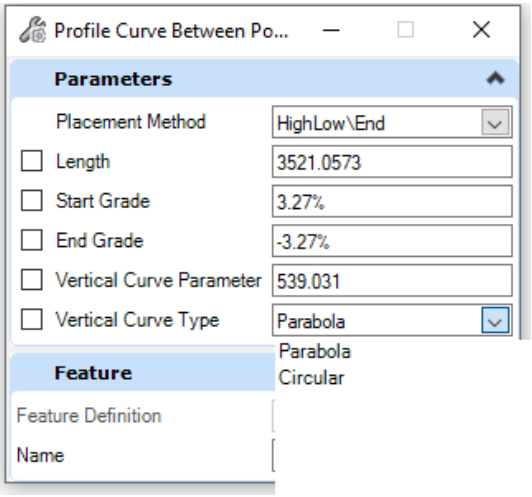


   B. There are several methods that can be used to place a curve.



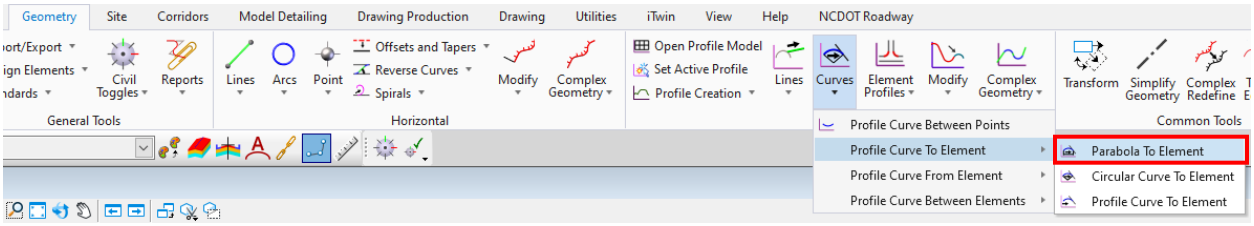
   HighLow\End may be the most useful, by allowing the user to specify a high or low point and then the end points of the curve

A. Note that in ORD there are also two types of vertical curves that can be used, parabolic or circular. NCDOT uses Parabolic curves for all design.



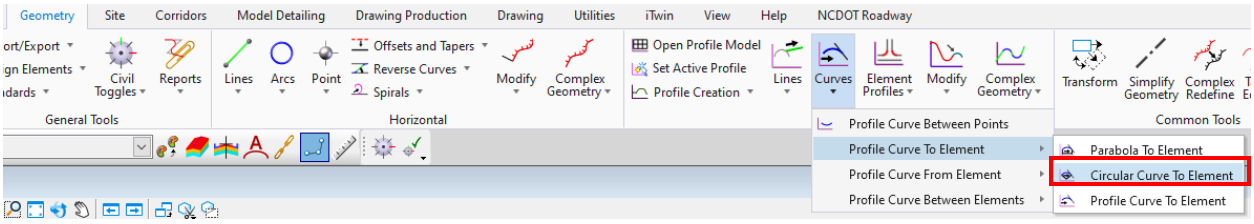
2. Parabola To Element

A. The **Parabola To Element** tool will draw a parabolic curve to an element from a set point.



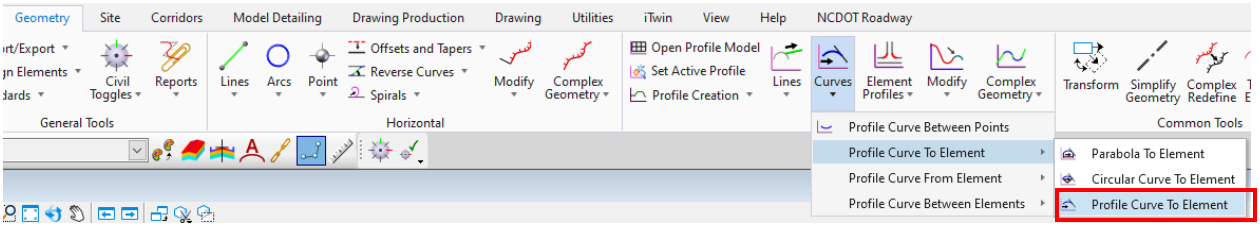
3. Circular Curve to Element

A. The **Circular Curve to Element** tool will draw a circular curve to an element from a set point, this tool will not be used by NCDOT roadway designers.



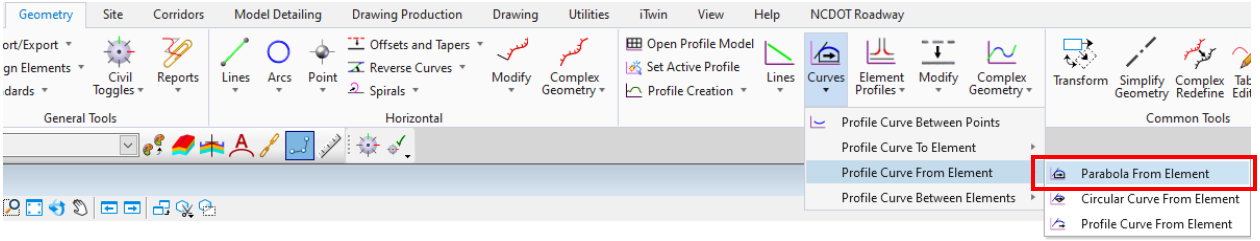
4. Profile Curve to Element

A. The **Profile Curve to Element** tool will draw either a parabolic or circular curve from a set point to a selected element and will also allow the user to specify an offset.



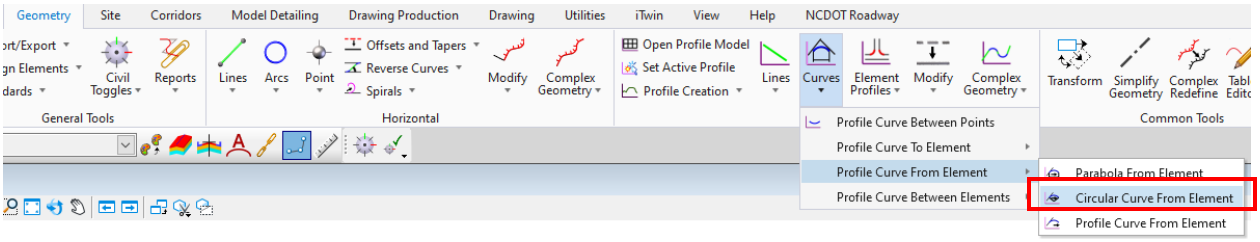
5. Parabola From Element

A. The **Parabola From Element** tool will draw a parabolic curve from a known point on a selected element. The offset is locked at 0.00'.



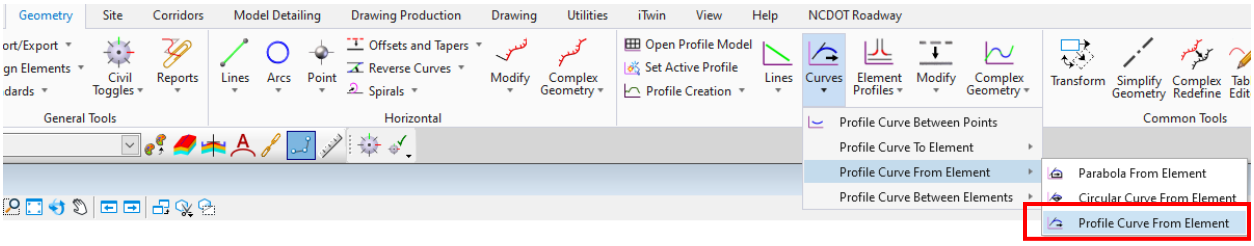
6. Circular Curve From Element

A. The **Circular Curve from Element** tool will draw a circular curve from a known point on a selected element, this tool will not be used by NCDOT roadway designers.



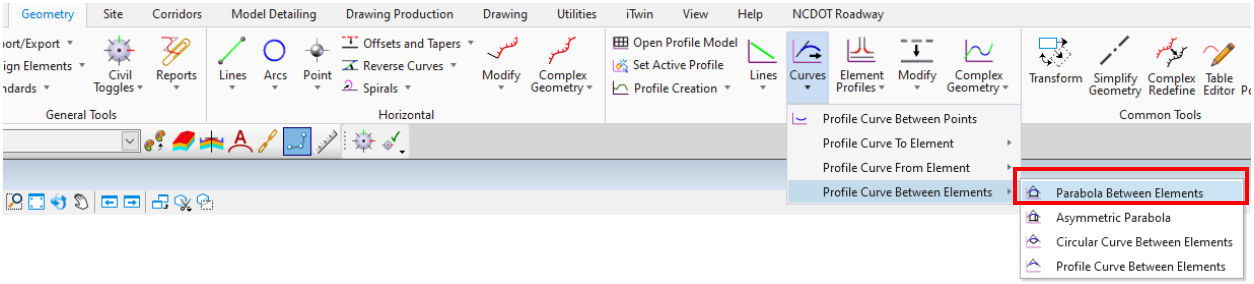
7. Profile Curve From Element

A. The **Profile Curve from Element** tool will draw a parabolic or circular curve from a known point on a selected element. This tool will also allow the user to specify an offset from the tangent element.



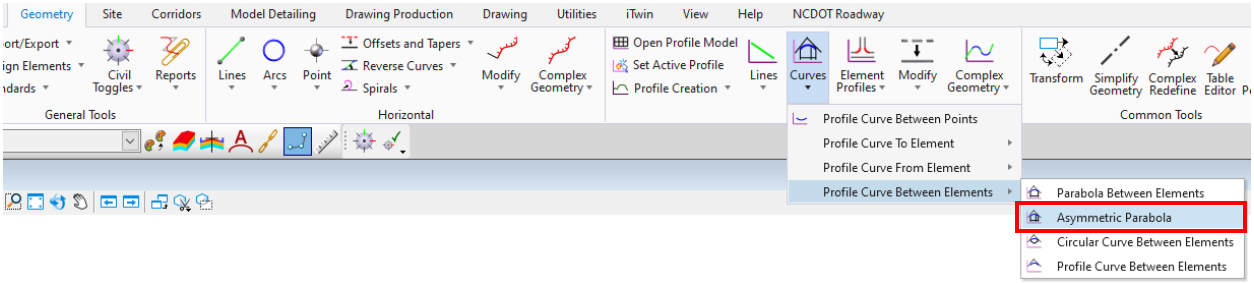
8. Parabola Between Elements

A. The **Parabola Between Elements** tool will allow the user to draw a parabolic curve between two profile elements with a set length. This tool will be commonly used by NCDOT roadway designers.



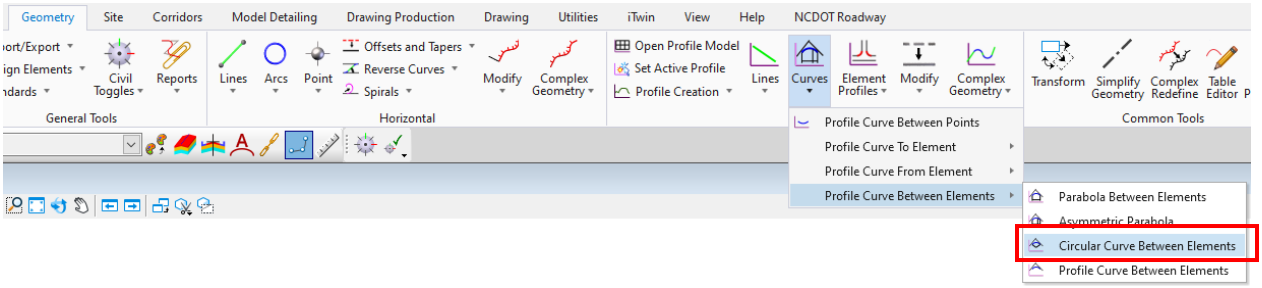
9. Asymmetric Parabola

A. The **Asymmetric Parabola** toll will allow the user to draw two parabolic curves of different lengths with no tangent between them in between two profile elements.



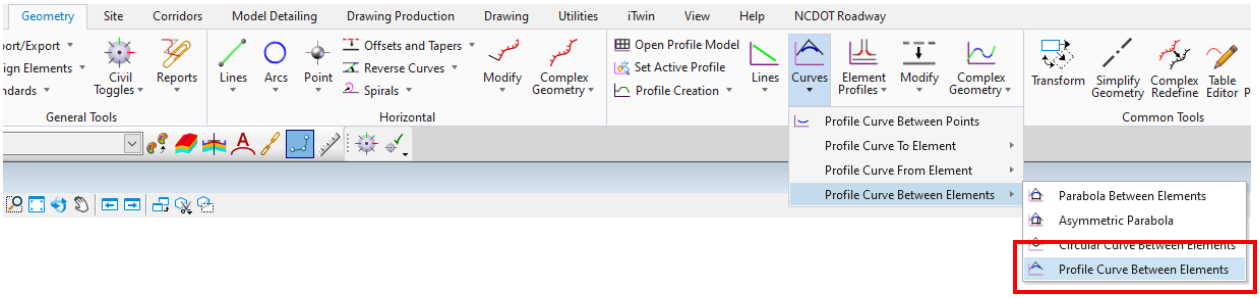
10. Circular Curve Between Elements

A. The **Circular Curve Between Elements** tool will draw a circular curve between two profile elements, this tool will no be used by NCDOT roadway designers.



11. Profile Curve Between Elements

A. The **Profile Curve Between Elements** tool will draw a circular or a parabolic curve between two profile elements, this tool also allows the user to specify a beginning and ending offset from each element.



Vertical Geometry Exercise – Profile Model View

In this exercise, you will learn how to navigate to the profile model view, where the profile design effort will occur.

The profiles in ORD are associated with a specific alignment. A single alignment can be associated with multiple profiles, but a single profile can only be associated with a single alignment, and a profile cannot be created without a horizontal alignment.

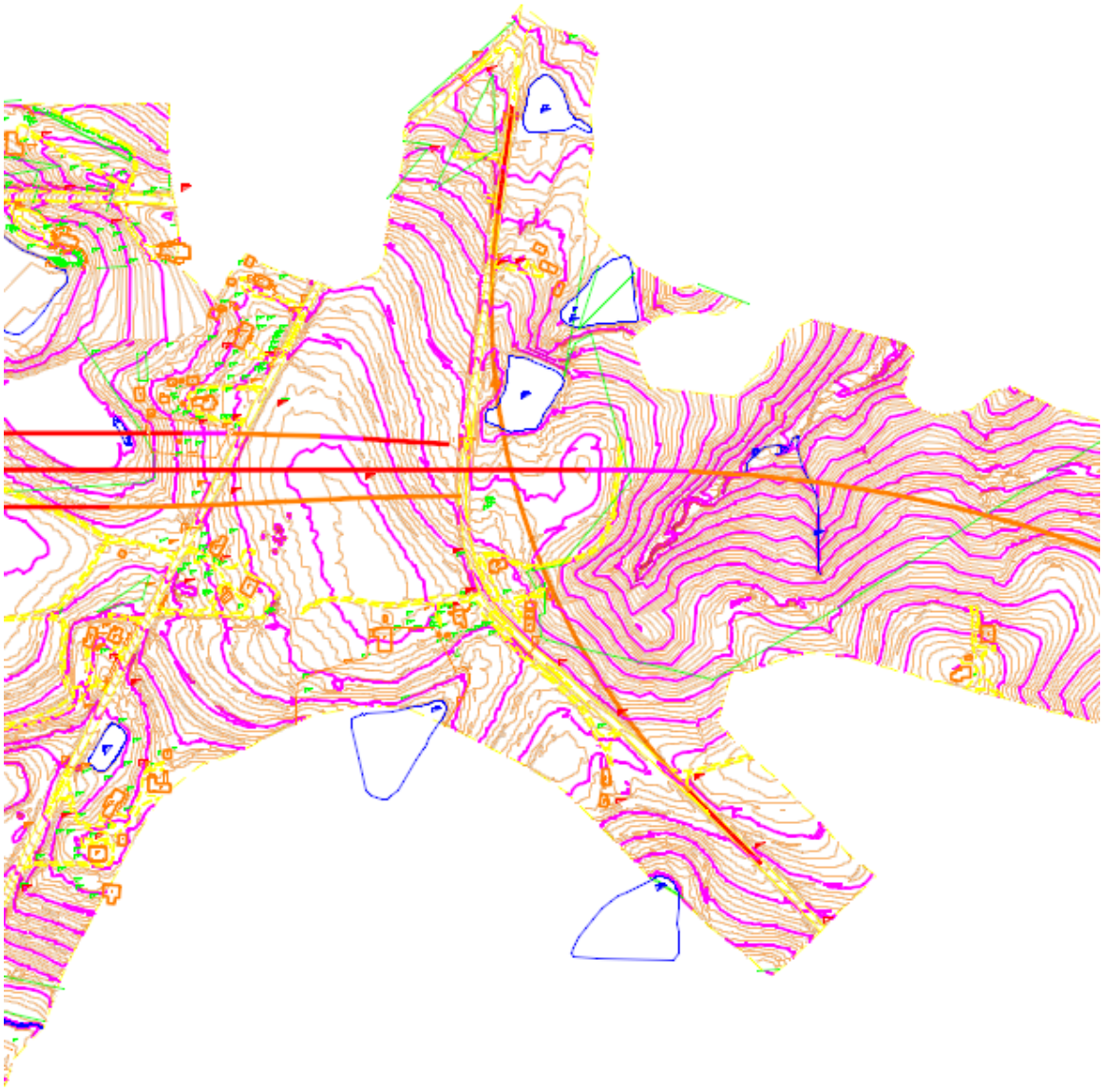
There will usually be multiple profile associated with a single horizontal alignments but only one profile can be active at a time.

Profile labeling and layout will not normally be shown in the Profile Model View, the Annotation will not be shown until the profile sheet layout.

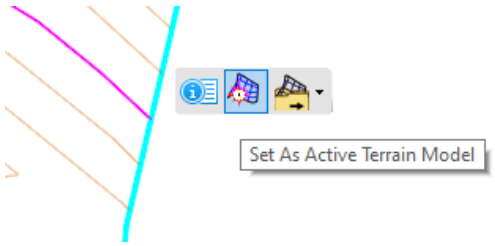
When designing a profile in ORD the design process takes place in a Profile Model. This Profile Model will be contained with the alignment file that has the horizontal geometry in it. The Profile Model is a special model with special display properties and is only used for profile design tasks. All the automatic Annotation will happen when the profile is placed on sheets. The sheet files will also be the location where any miscellaneous graphics are added.

1. Initiate the Profile Model View

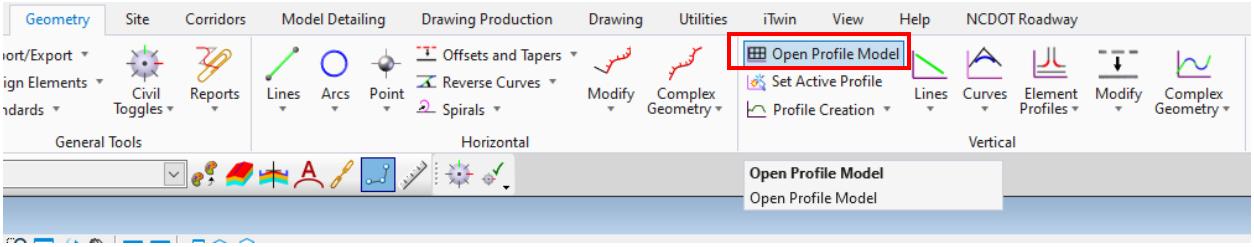
A. Open the ***R-2635C_RDY_ALG_Y11.dgn*** file from *C:\NCDOT Training\Roadway\Module 4 Vertical Alignment\R-2635C\Roadway\Alignment*. This is the same file created in the Horizontal Alignment training module. This file will already have the Final Survey file and the Existing Terrain Model attached.



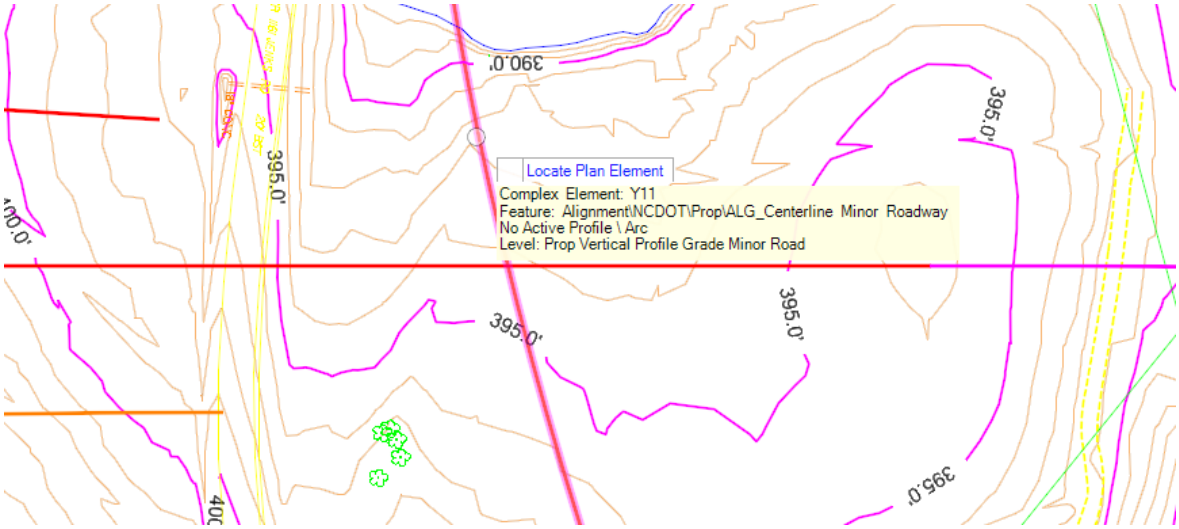
B. Set the Existing Terrain Model to active.
   - Highlight the boundary element and activate the pop up menu by moving the cursor off and then back on to the element.
   - Select the Set As Active Terrain model icon



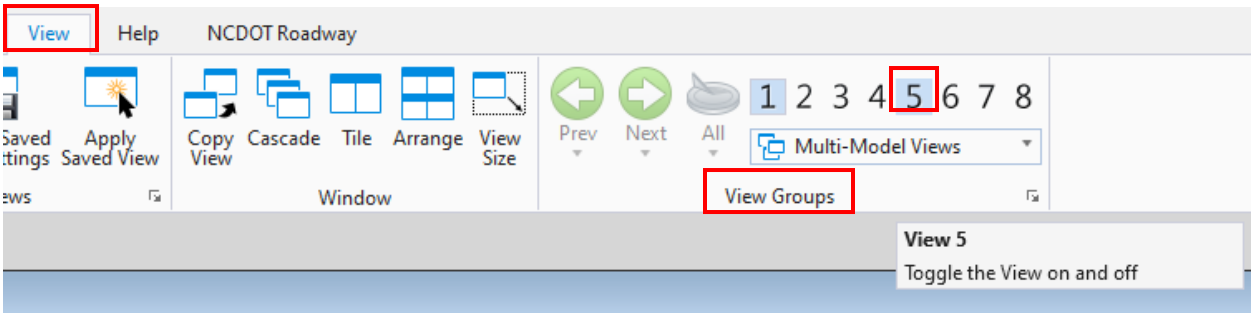
C. Select the **Open Profile Model** icon from the *Vertical* Section of the *Geometry* ribbon.



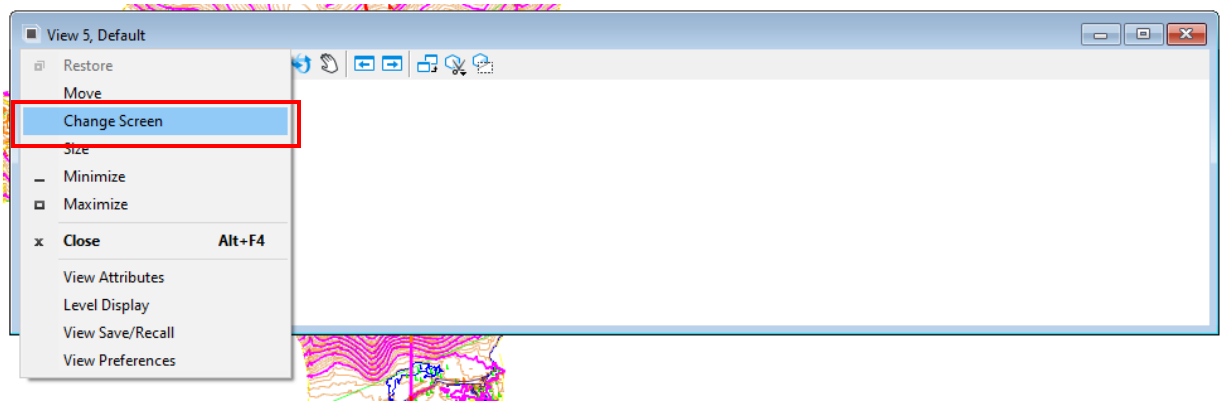
D. At the prompt to Locate Plan Element left click on the Y11 Alignment, this will set the alignment that will be associated with the profile. Y11 goes over the L line and is north of the two collector distributor roads.



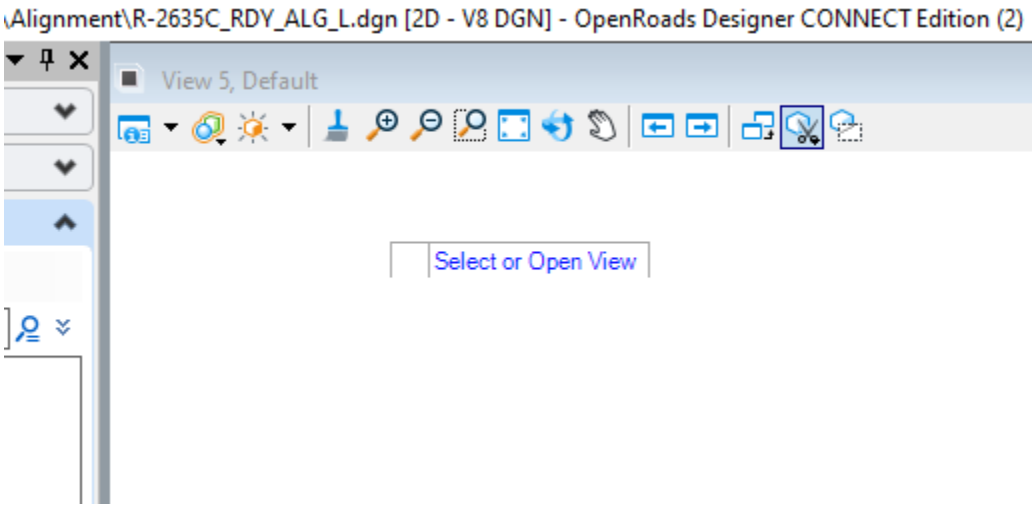
E. The next prompt is Select or Open View. If there is another view window open already move to the next step. If not, locate the View Groups section of the View ribbon and select 5 to open view window 5. It is not important which window is opened.



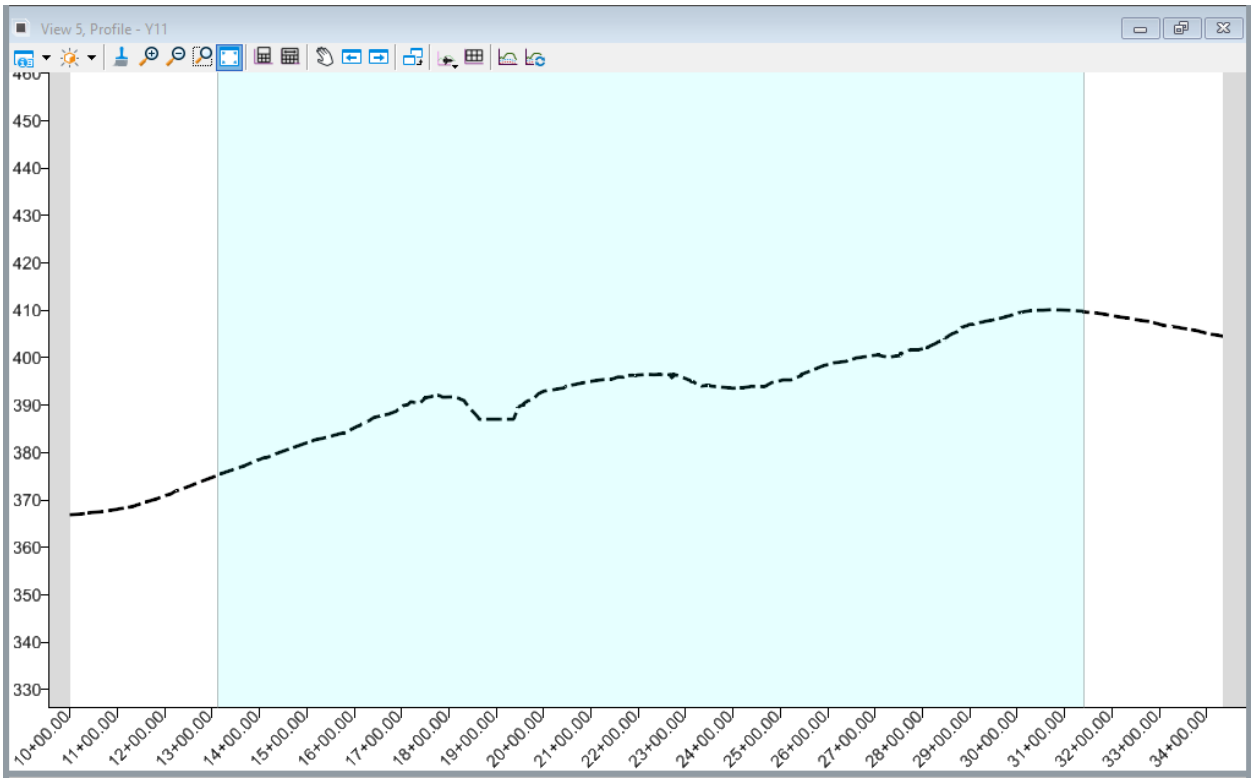
If necessary, change screens by selecting from the View Window 5 drop down menu, and maximize the view 5 window.



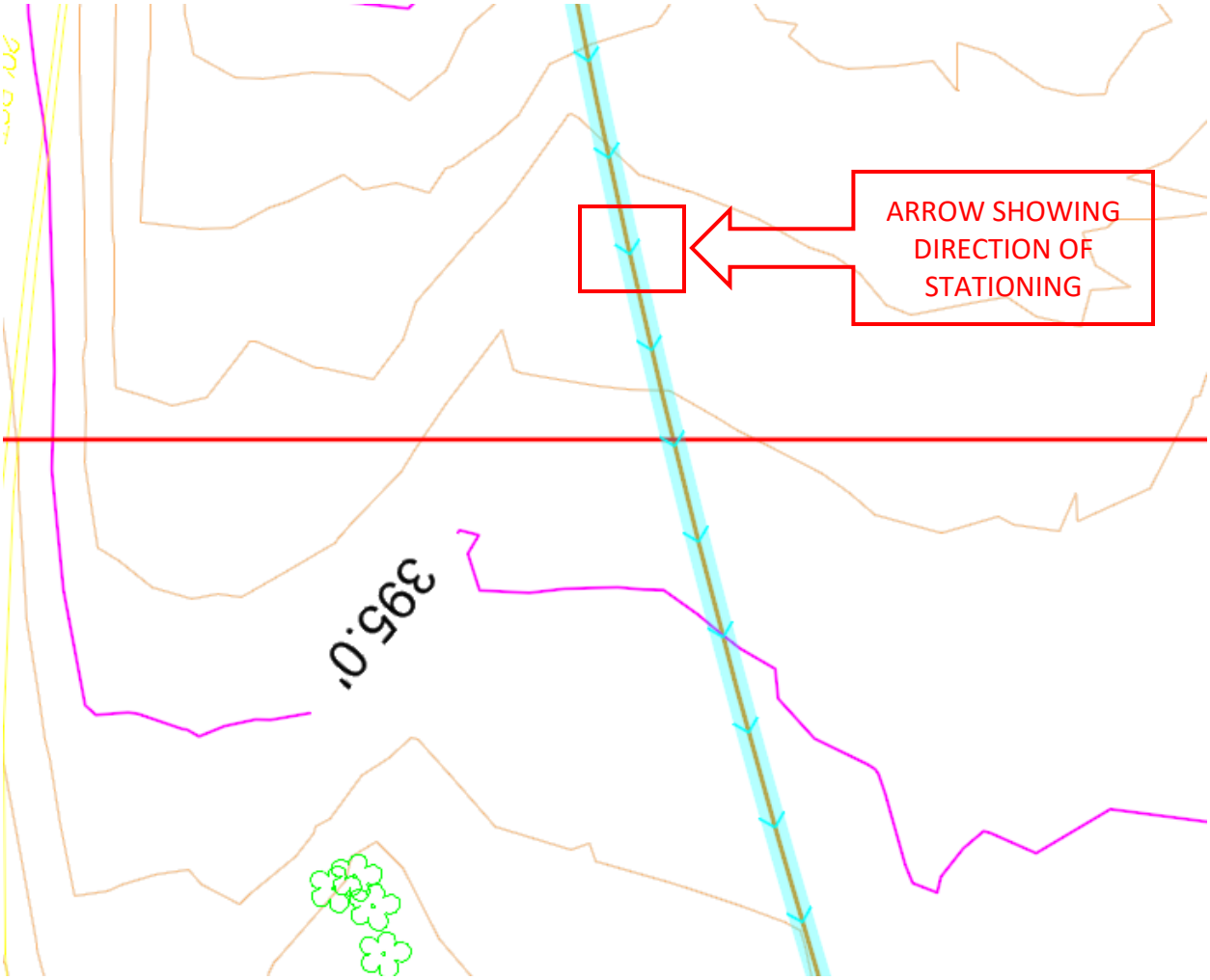
F. Left click inside the View 5 window to select this window as the profile model.



G. This will complete the Profile Model View Setup.

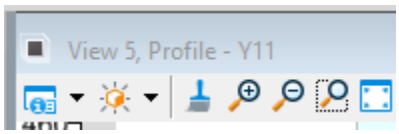


H. Note that in the plan view the alignment to which the profile is associated is highlighted and there are arrows indicating the direction of the stationing.

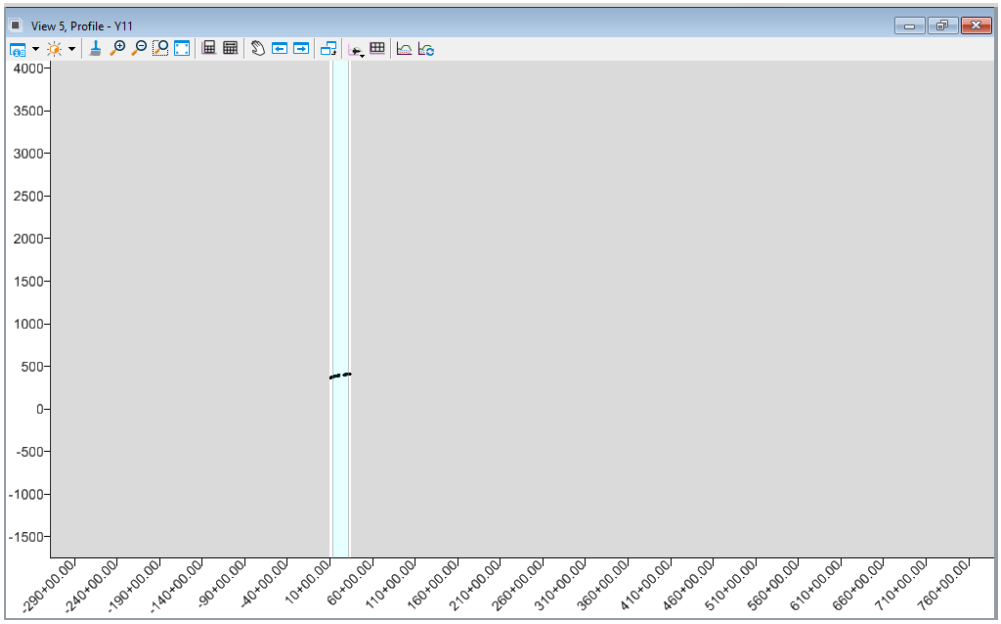


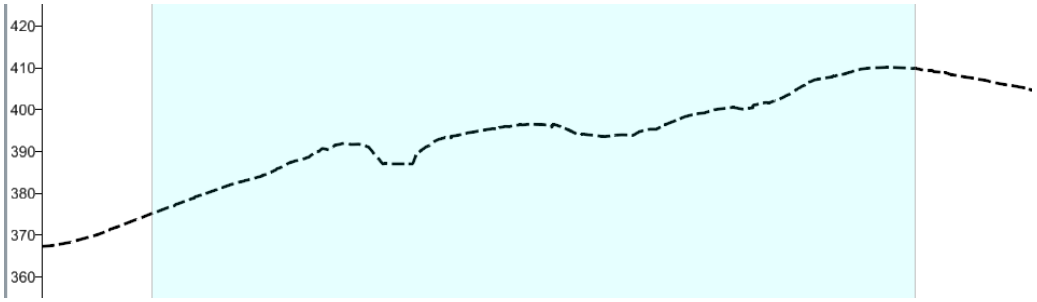
2. Profile Model View Symbology

A. Note that the title of the view 5 window has changed from Default to Profile Y11

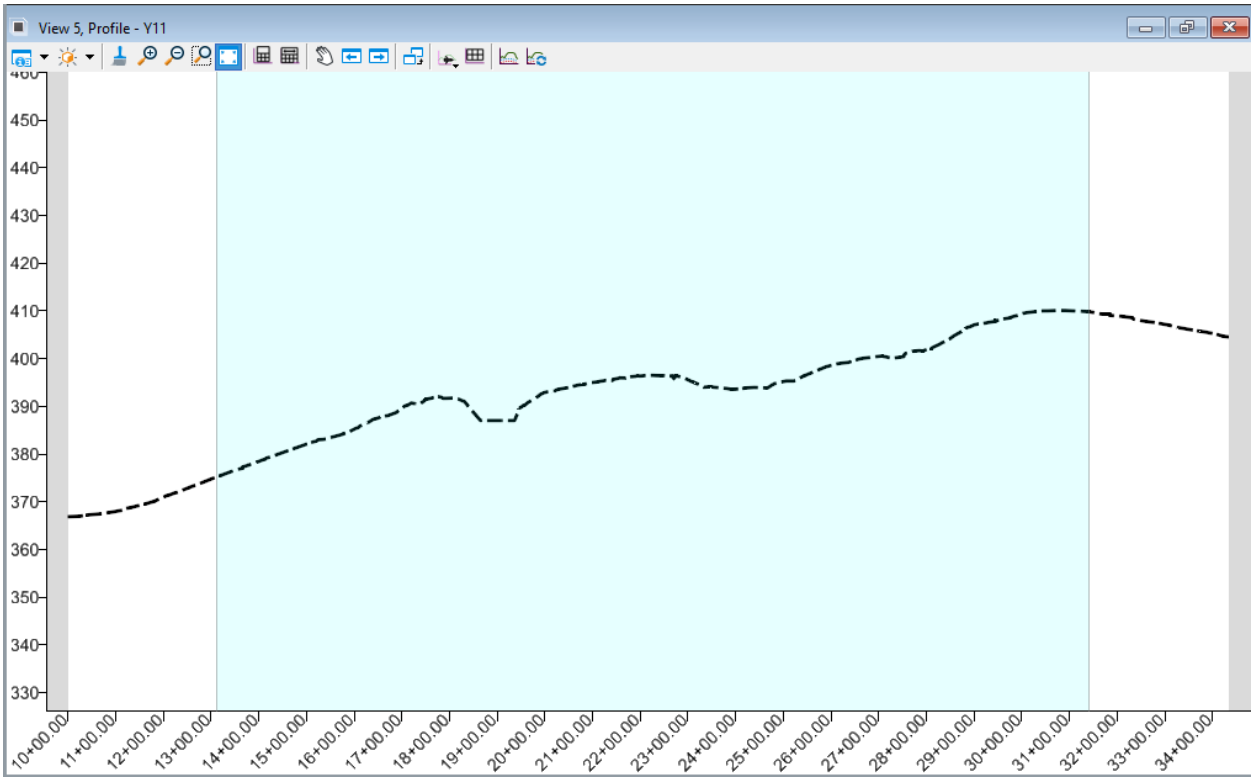


B. The Profile Model is a dynamic view it is only meant for profile design. By Zooming out and in the user can see that the elevations shown, and the station range changes dynamically.



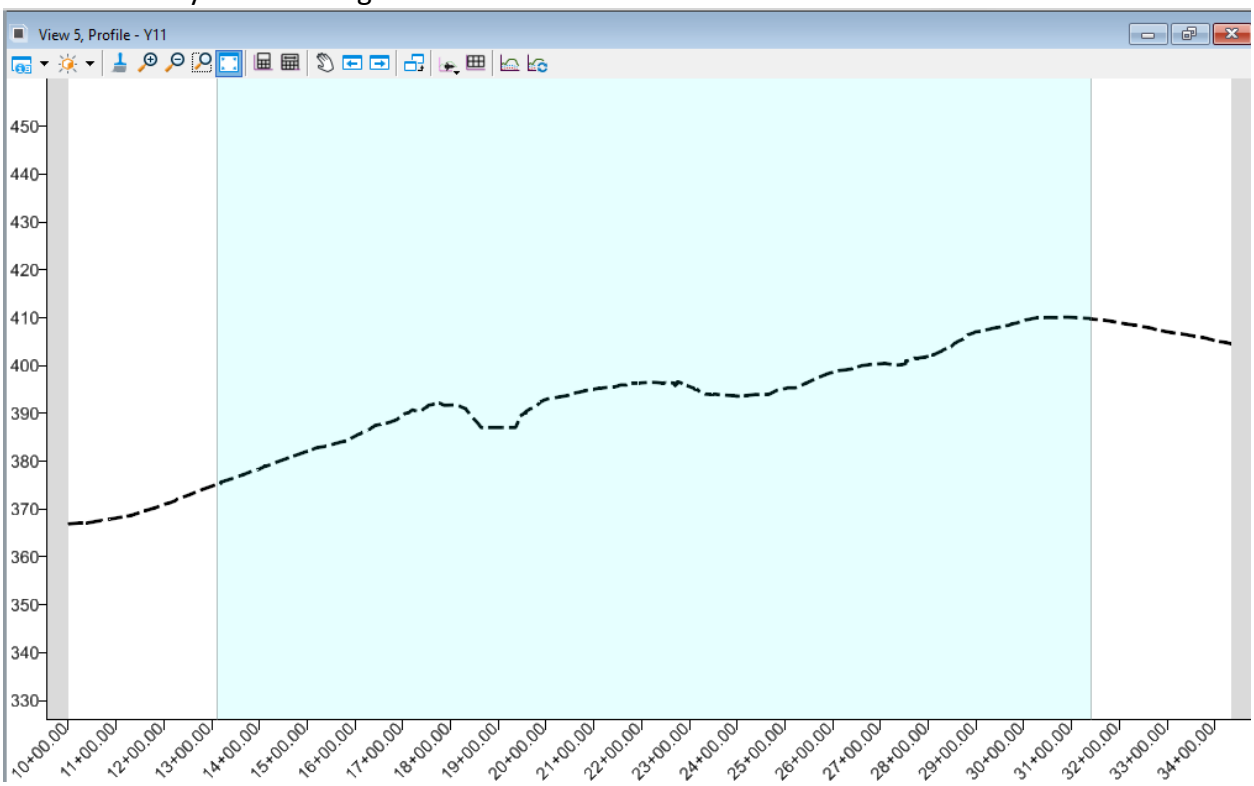


C. Using the fit view command will resize the model to fit the limits of the active alignment in the window.

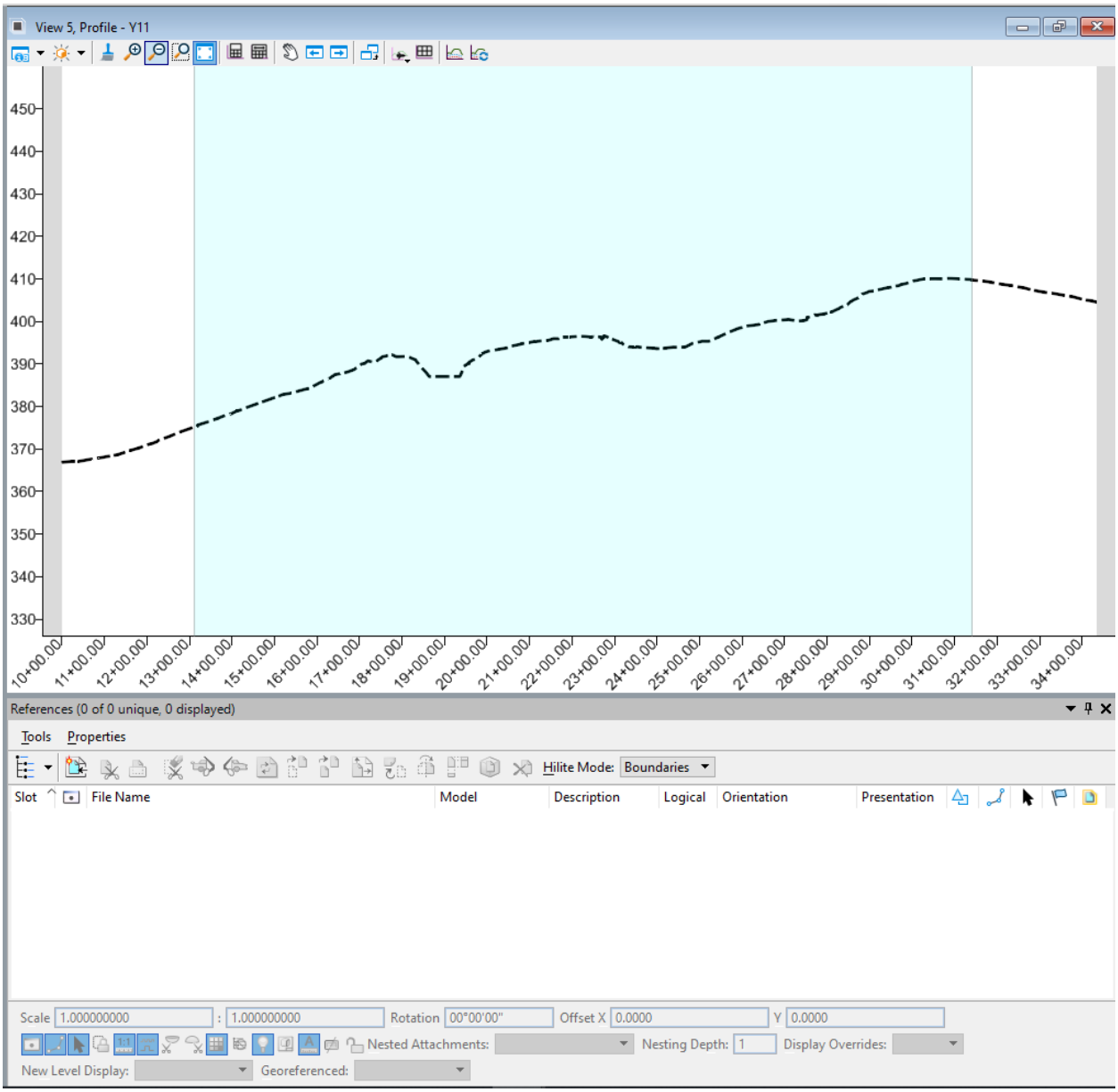


D. The heavy dashed line is the representation of the Existing Terrain Model contained in the ETM file that was set active. This could be any terrain model, a proposed or existing surface. It will always be a representation of the Active Terrain model.

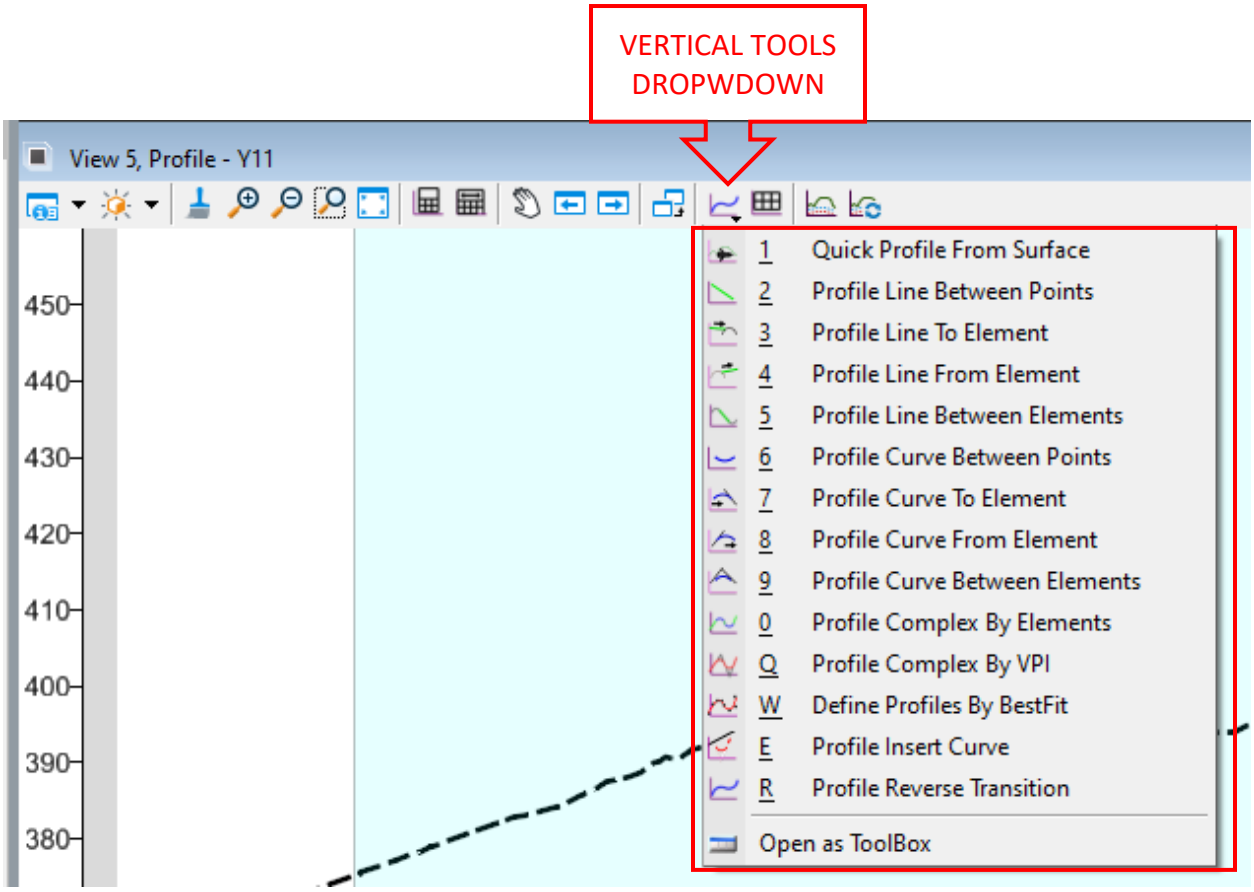
E. Note the colored band, this represent location of a curve (spirals will show as a different color) and will assist the design by indicating areas where super changes may be occurring.



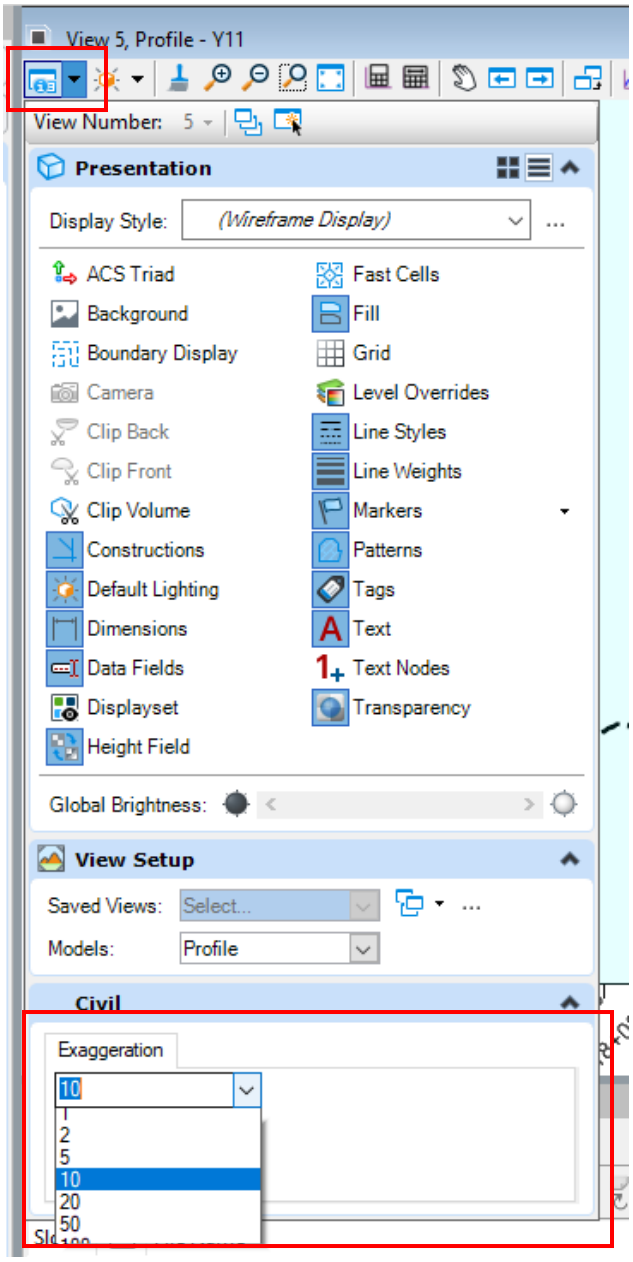
F. Also, note that when the Profile Model View is active that the list of reference files changes, this is a feature of CONNECT, each model can have an independent list of reference files. In general, no reference files should be attached to the Profile model view.



G. Left click and hold the Vertical Geometry Tools icon in the Profile model window to get a drop down of the most common vertical profile tools.

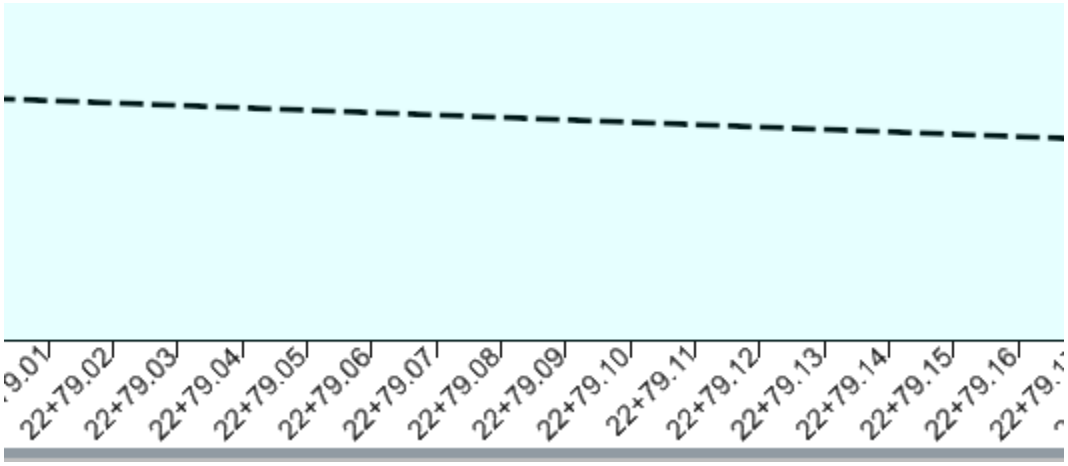


H. The profile exaggeration can be adjusted under View Attributes of the Profile Model window.



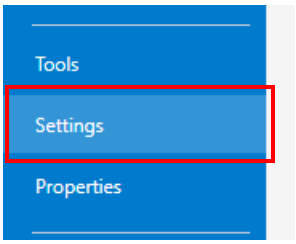
I. The exaggeration can also be adjusted using the :
   - Shift+Mouse Wheel – Maintain the current horizontal axis units
   - Ctl+ Mouse Wheel – Maintain the current vertical axis units.

J. Zoom in and out can be accomplished using the Mouse Wheel. As shown below the user can zoom in to 0.01’ increments or more.

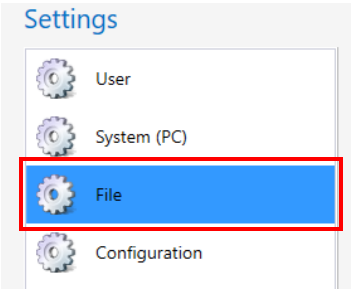


K. The formatting and precision is controlled through the Civil Formatting dialog options.

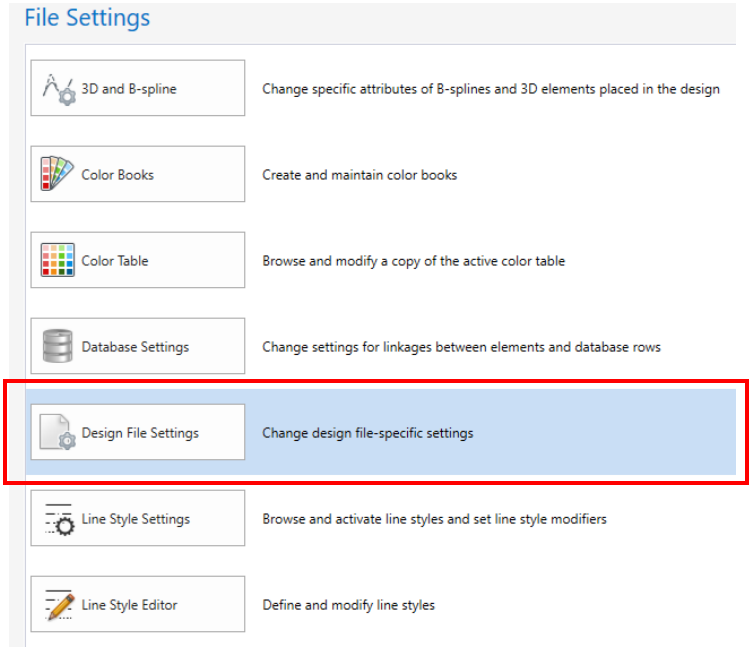
- Got to File → Settings



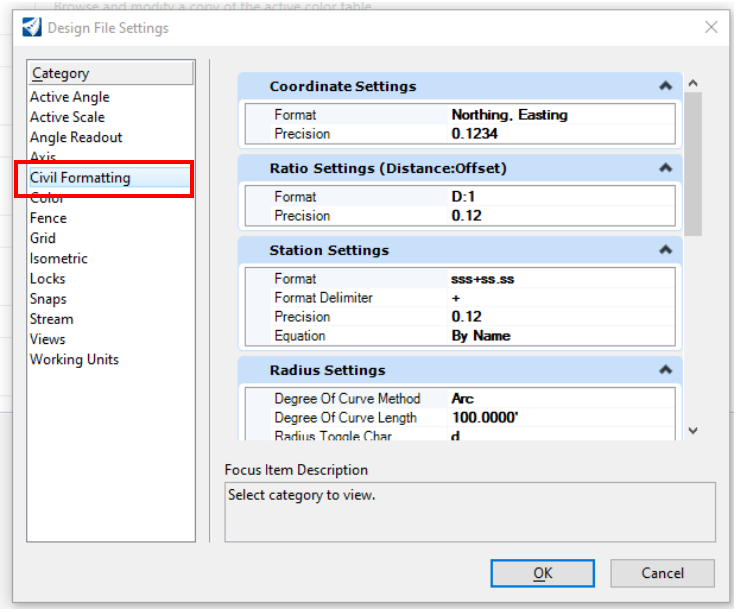
- Select File. These are the setting for the current design file.



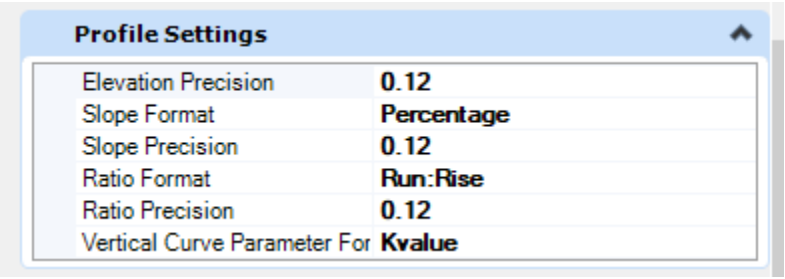
- Select Design File Settings



- Select Civil Formatting



- This has settings for the profile unit display, in addition this has the settings for the display of many other civil functions

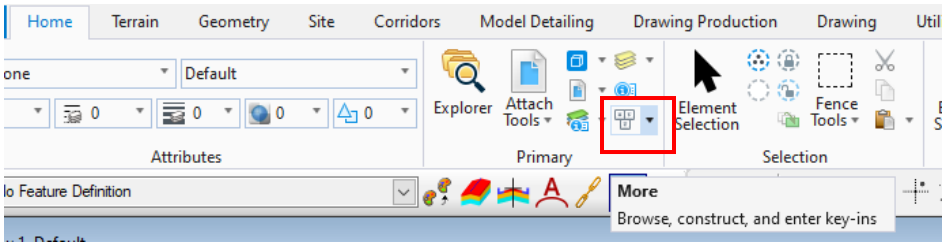


Vertical Geometry Exercise – Civil AccuDraw

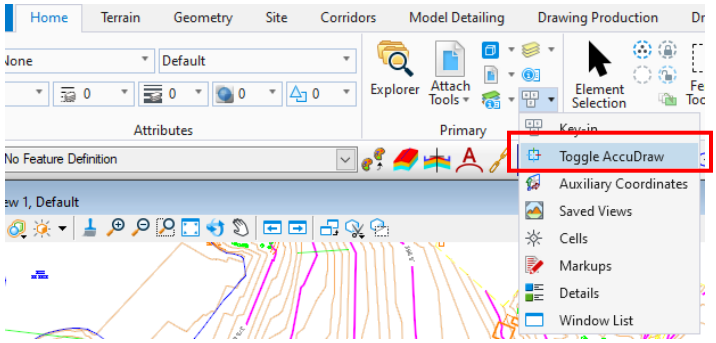
Civil AccuDraw is a tool that will allow the user to precision input information to set a point in space. Civil AccuDraw can be used in the Horizontal or Vertical design models this discussion will focus on the capabilities when using Civil AccuDraw in the vertical design model. It is not a requirement to use Civil AccuDraw to design horizontal or vertical alignments but one setting where it will be very helpful is the Profile Complex by PI process covered in the next section.

This section is not meant as a full tutorial on the use of Civil AccuDraw, only an overview to assist with the precision input of VPIs in the vertical profile design model.

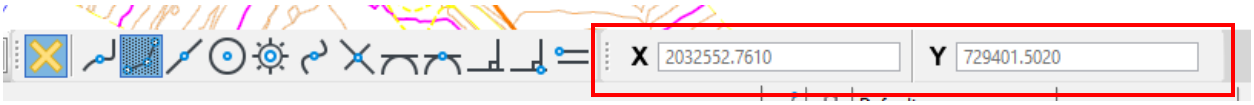
1. **Civil AccuDraw**
   A. Civil AccuDraw and MicroStation AccuDraw cannot both be toggled on at the same time. Toggling on Civil AccuDraw will automatically toggle off MicroStation AccuDraw, but MicroStation AccuDraw will restart when Civil AccuDraw is toggled off.
   B. Open the ***R-2635C_RDY_ALG_Y11.dg*** design file.
   C. MicroStation AccuDraw can also be toggled off in the dgn file until the user restarts it under the **More** section of the *Primary* tool group on the *Home* Ribbon. Note that the icon displayed here will be the last tool selected from this group but, the location of the More section will always be in the lower right corner of the Primary tool group. This can be found on multiple ribbons as well.



   D. Select the Toggle AccuDraw to turn AccuDraw off if it is on.



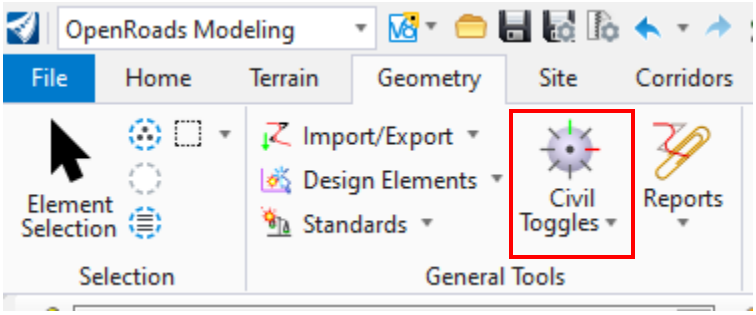
E. If MicroStation AccuDraw is ON the familiar XY dialog box will be displayed.



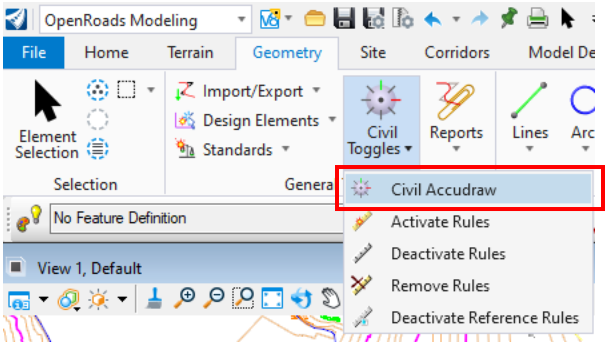
F. If MicroStation AccuDraw if OFF the dialog will not be visible. Note that the location of the dialog is user specific.

G. Many users may find leaving MicroStation AccuDraw off when designing profiles to be preferable, but it is not a requirement and may prove useful for some users, this will be a personal preference.

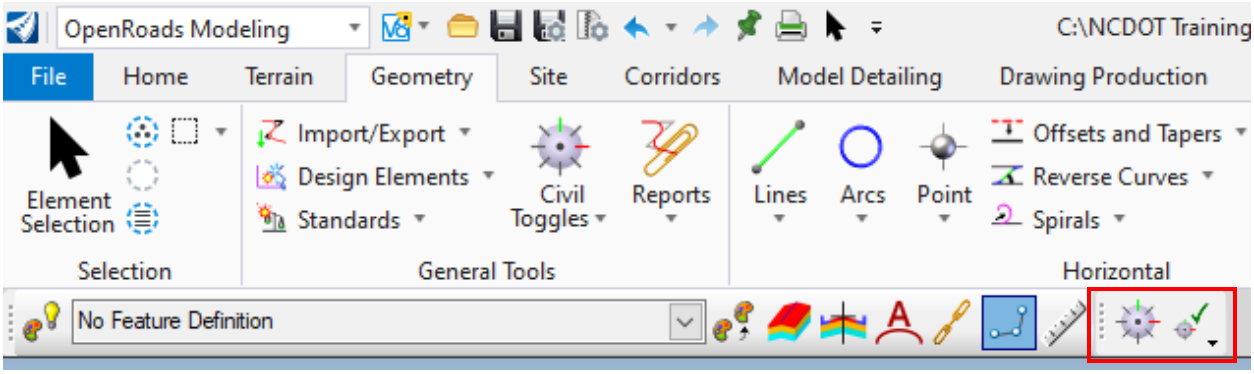
H. Civil AccuDraw is in the *General Tools* section of the *Geometry* ribbon.



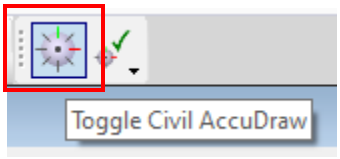
I. Select Civil AccuDraw will activate the Civil AccuDraw toolbar.



J. This tool bar can be docked next to the Feature Definition Tool bar for ease of use.

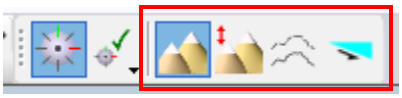


K. Select the Toggle Civil AccuDraw icon to activate Civil AccuDraw

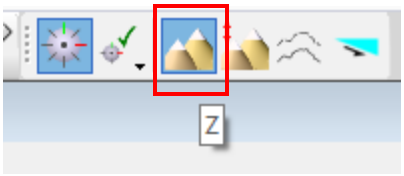


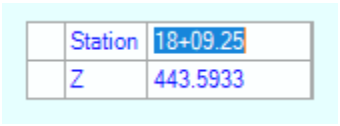
L. At this point additional Toggles will appear and they will be different depending on which model is the Active window. If the plan view horizontal window is active the horizontal design AccuDraw toggles will appear.

M. By clicking on the Profile model, the toggles will change to the vertical design AccuDraw toggles.

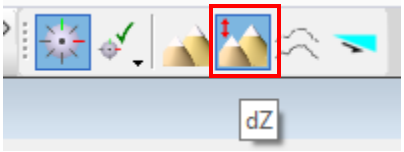


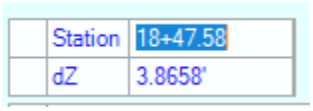
N. These toggles will provide the user with various input choices that can be used in conjunction with other vertical geometry tools for precision input of stations, elevations, and slopes. The Z toggle will activate a pop-up display that can be used to input Station and Z (elevation)



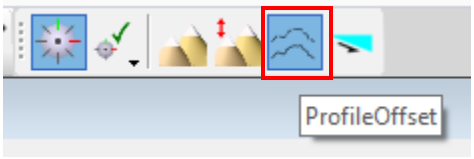


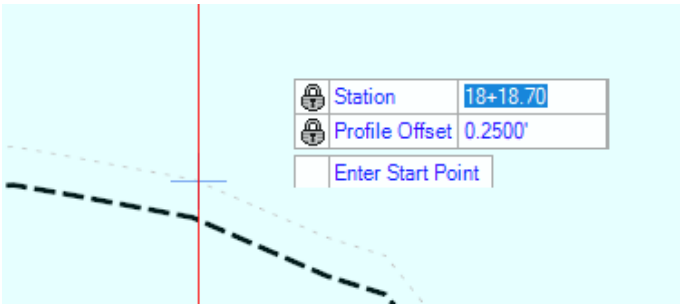
O. The dZ toggle will activate a pop-up display that will allow the user to input a station and an elevation difference from a starting point.





P. The Profile Offset toggle will activate a pop-up display that will allow the user to specify a start station and an offset from the active profile, this can be the existing ground or a proposed profile.





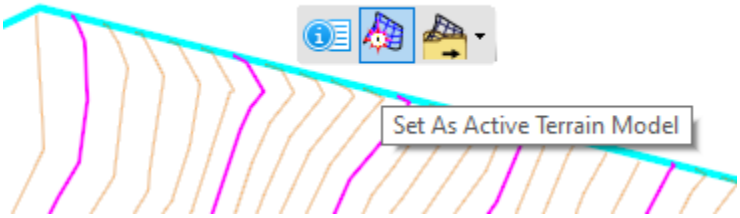
Q. The slope toggle will allow the user to specify a station and a slope based on a starting point.

R. Civil AccuDraw is not a standalone tool, it will be used in conjunction with other geometry tools to allow for precision input of points based on other references, baselines, elevations, slopes etc. Civil AccuDraw is not a requirement to produce vertical or horizontal designs, some users may find it easier to use in certain situations.

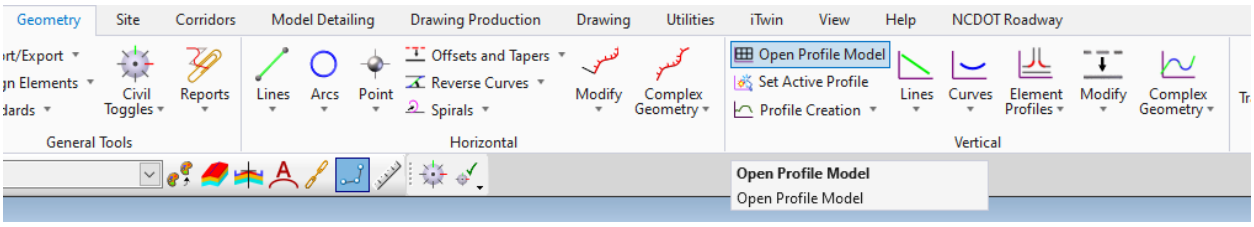
Vertical Geometry Exercise – Profile Complex By PI

In this exercise, you will learn how to place a complex vertical profile element by using the PI method. This is like the horizontal geometry exercise of placing a horizontal alignment by know PI. In this exercise a station and elevation will be used to set a VPI and then a vertical curve will be placed to complete that section of the vertical alignment. Additional VPIs and curves will be placed until the alignment is complete.

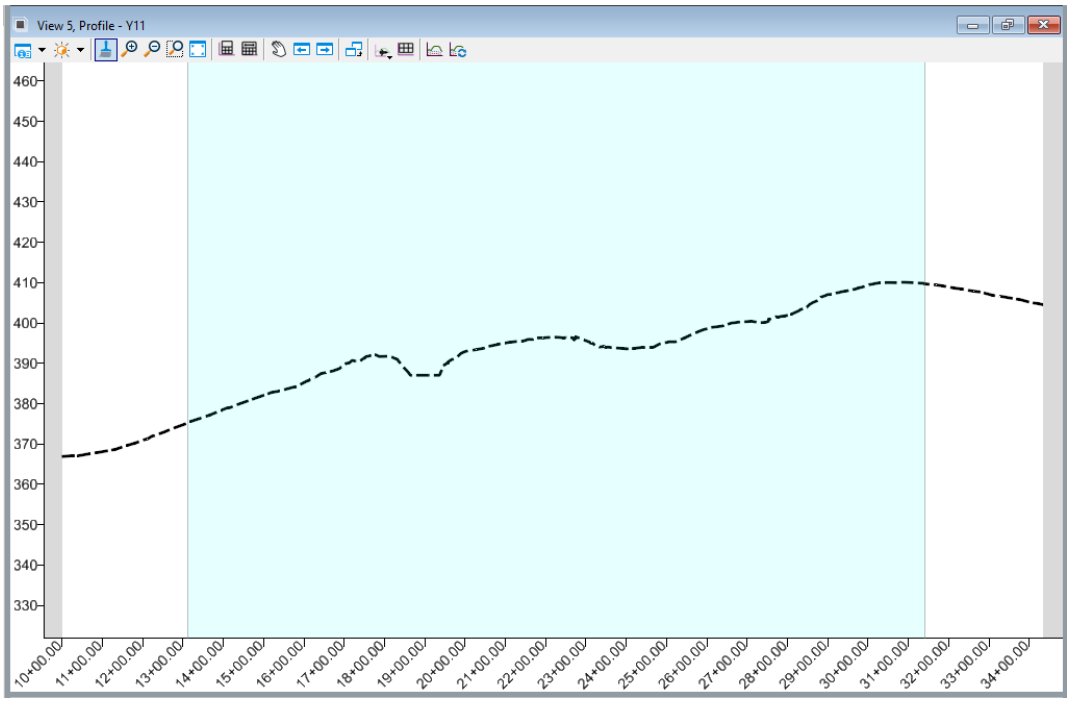
1. **Open the Profile Model View**
   A. Open the ***R-2635C_RDY_ALG_Y11.dg*** design file.
   B. Set the Existing Terrain Model as the Active Terrain Model



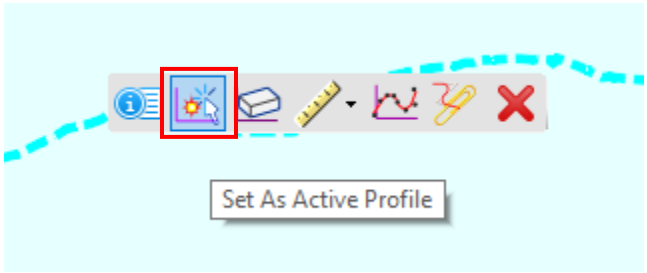
   C. Open the Profile Model View



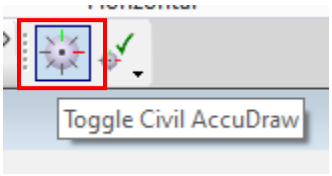
D. The profile Mode View should display with the existing ground line shown.



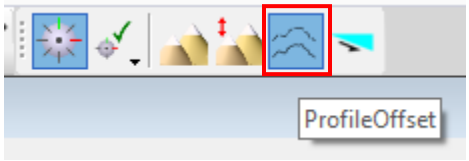
E. Set the existing ground profile as the Active Profile. This is like setting the existing terrain model active. Highlight the profile, move the cursor off the profile line and then back on to the line. The context menu will display, and the user can left click on the icon to set the profile as Active.



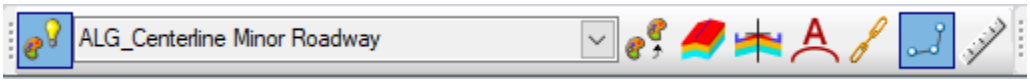
F. Toggle ON Civil AccuDraw



G. Select the Profile Offset setting

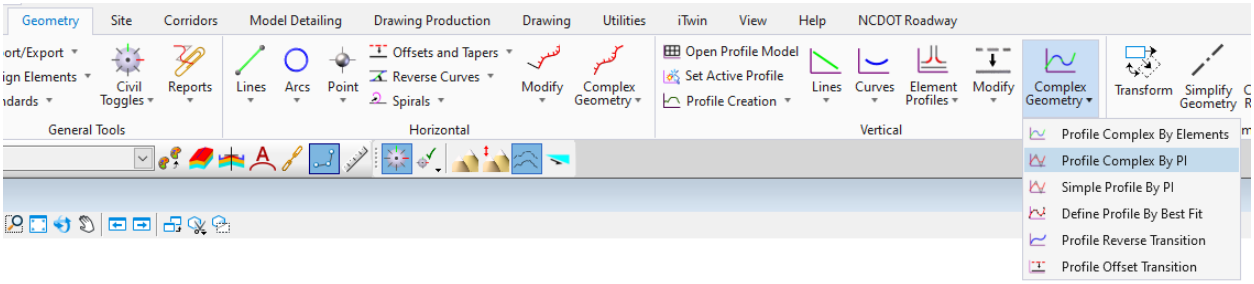


H. Set the Feature Definition to ALG_Centerline Minor Roadway and toggle ON use Active Feature Definition.



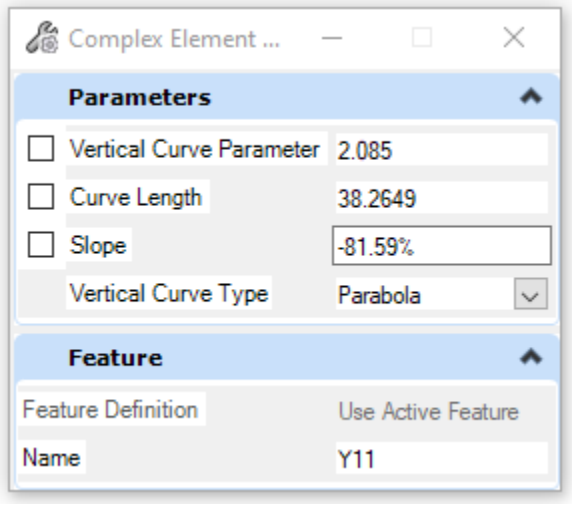
2. Profile Complex by PI

A. Start the **Profile Complex by PI** tool from the Complex Geometry tool group located in the *Vertical* section of the *Geometry* ribbon.

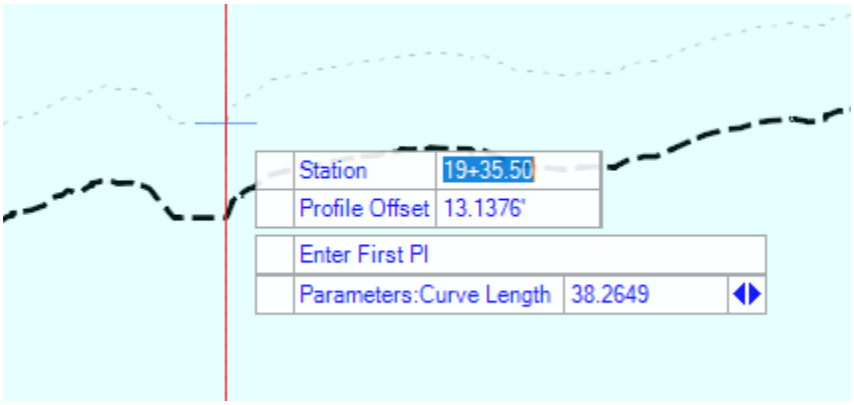


B. In the dialog box

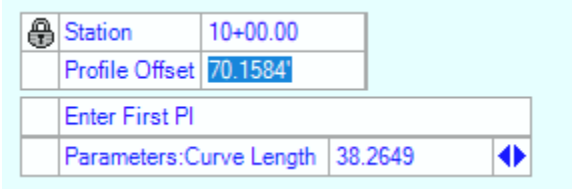
- Set the Vertical Curve Type to Parabola
- Set the Name to Y11, this should match the name of the horizontal alignment for centerline profiles



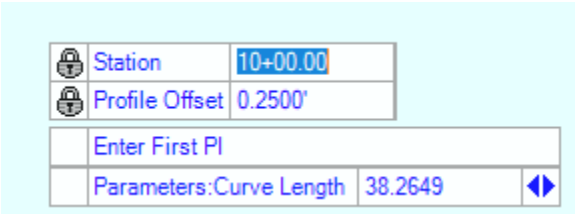
C. Set the Profile Model view Active by clicking on the window and use the TAB key to set the focus into the station field of the AccuDraw pop up.



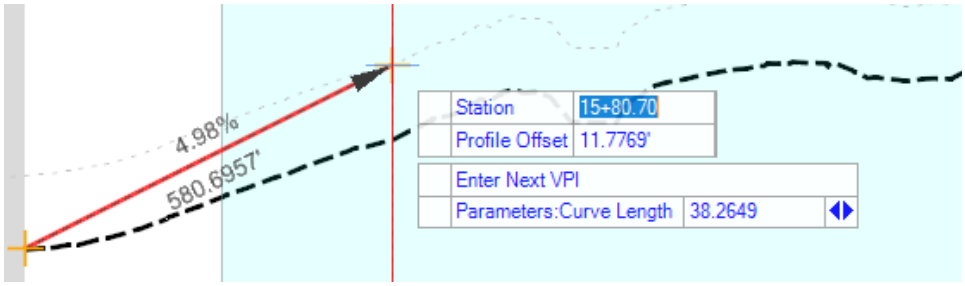
D. Enter 10+00.00 for the station and press ENTER to lock



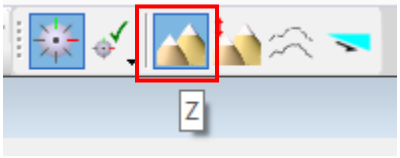
E. Enter 0.25’ for the Profile Offset and press ENTER to lock. This will set the starting profile point at Station 10+00 and 0.25’ above the existing ground.



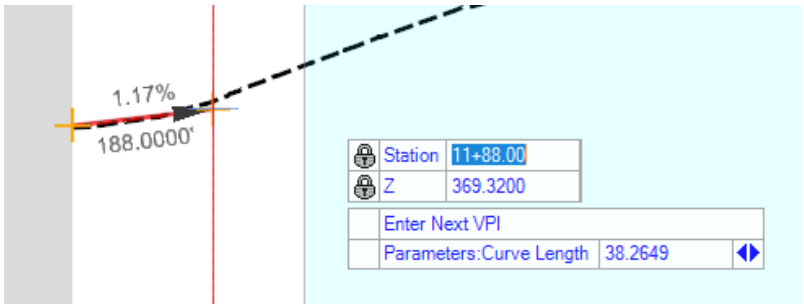
F. Left click to accept the starting point.



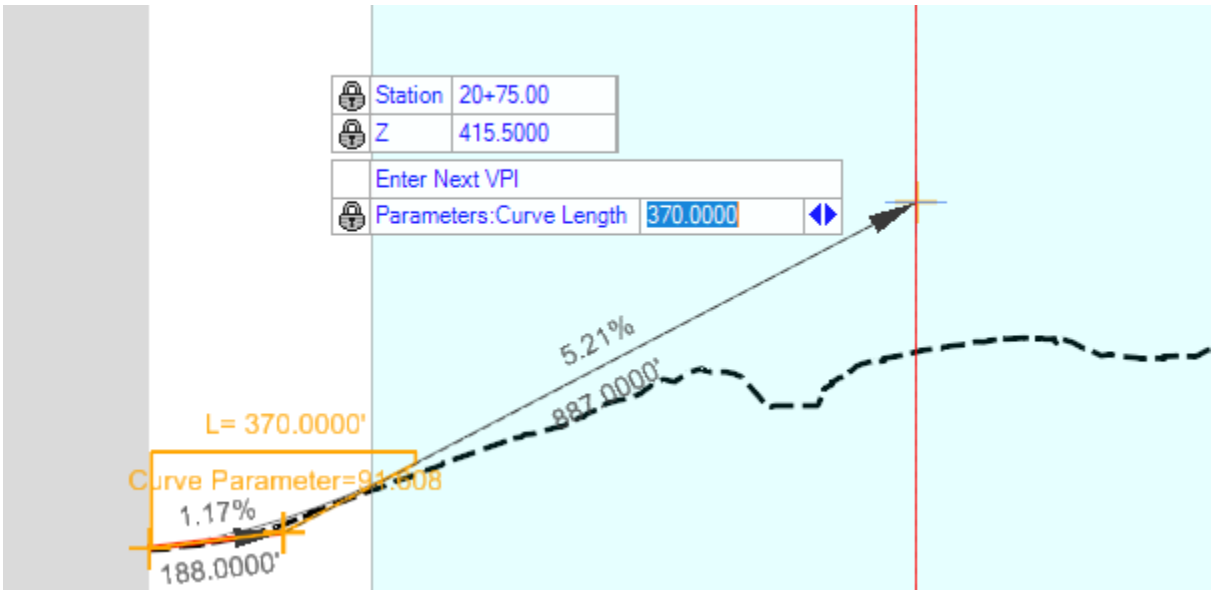
G. Change the Civil AccuDraw toggle to the Z setting to allow for precision input of Station and Elevation. This will not interrupt the **Profile Complex by PI** tool.



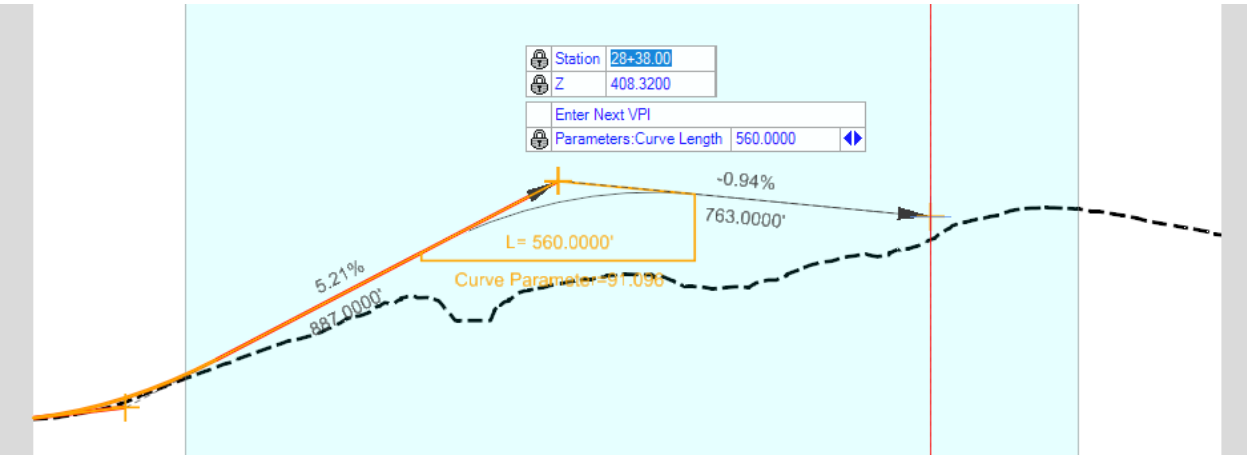
H. In the Profile Model view at the heads-up prompt enter
- Station = 11+88.00
- Z = 369.32’
- Left click to accept the VPI point



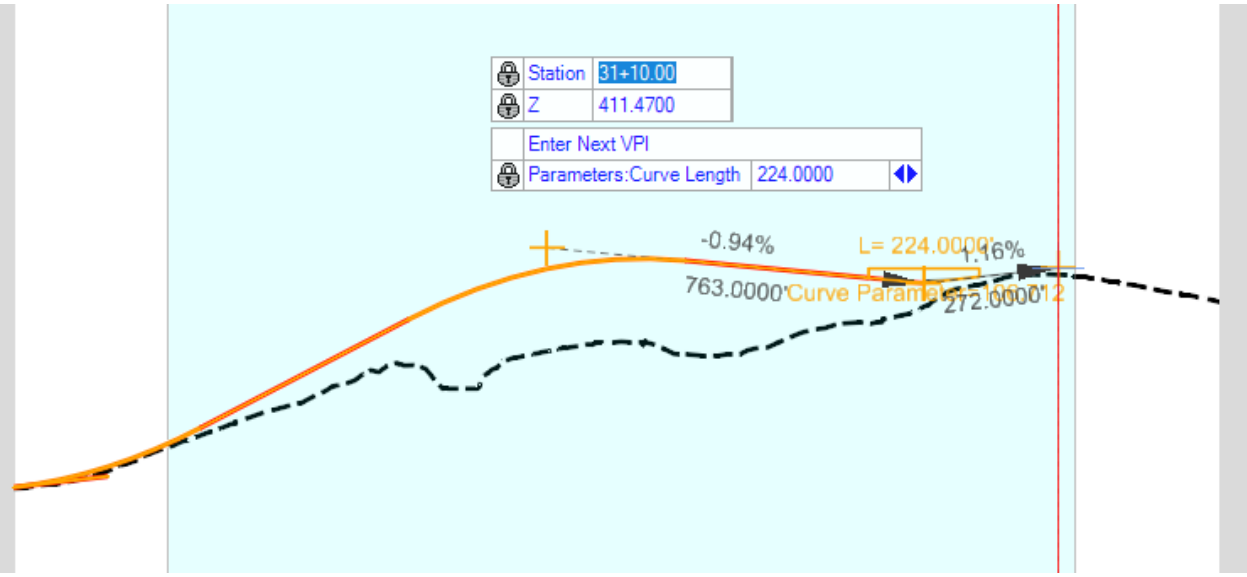
I. For the next VPI enter
- Station = 20+75.00
- Z = 415.50’
- Parameters Vertical Curve Length = 370’
- Note that the vertical curve length specified is for the vertical curve with a VPI at station 11+88. Both the back and ahead grade must be established with this workflow before the vertical curve is placed.
- Left click to accept the VPI at Station 20+75 and set the vertical curve at Station 11+88.



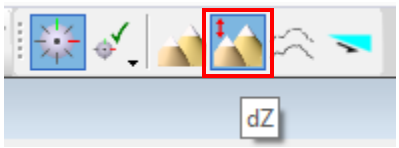
J. For the next VPI enter
- Station = 28+38.00
- Z = 408.32’
- Parameters Curve Length = 560’
- Left click to accept VPI and place Curve



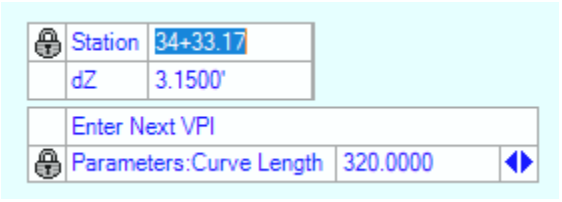
K. For the next VPI enter
- Station = 31+10.00
- Z = 411.47’
- Parameters Curve Length = 224’
- Left click to accept VPI and place Curve



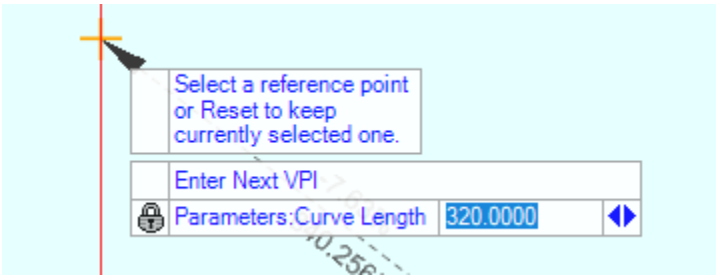
L. For the final VPI select the dZ toggle in Civil AccuDraw. This is an alternate method to set a final elevation on based on a reference point.



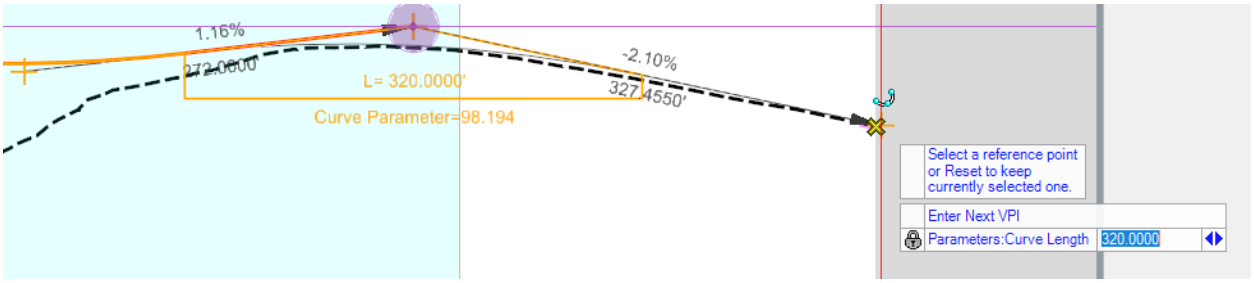
M. Set the Station to 34+33.17 and ENTER to lock.



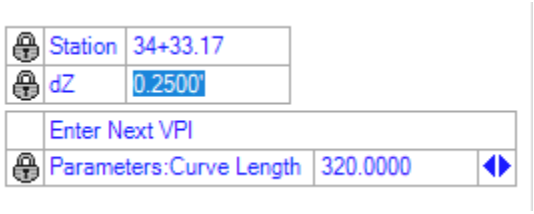
N. In the dZ field type the Letter 'O'. This will allow the user to specify an origin point that will then be used to calculate the elevation of the VPI based on a dZ value.



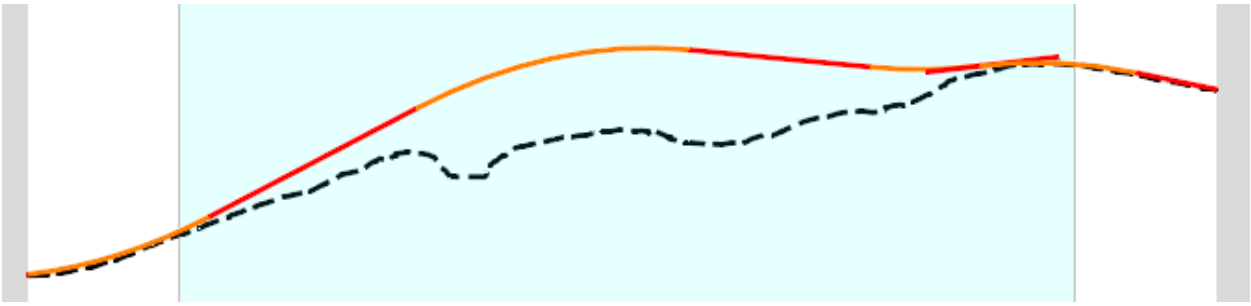
O. Snap to the end of the existing ground line to select it as a reference point.



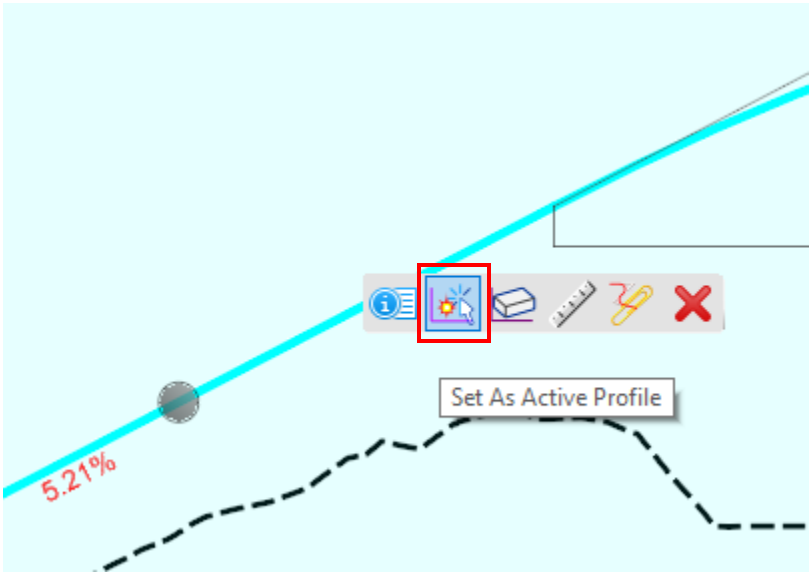
P. This will bring back the dZ dialog. Tab to the dZ field and enter 0.25’ to set the final VPI 0.25’ above the reference point.



Q. Enter the final Vertical Curve length as 320’ and Left click to accept the final VPI and set the final vertical curve length. Right click to end the tool and finish the profile.

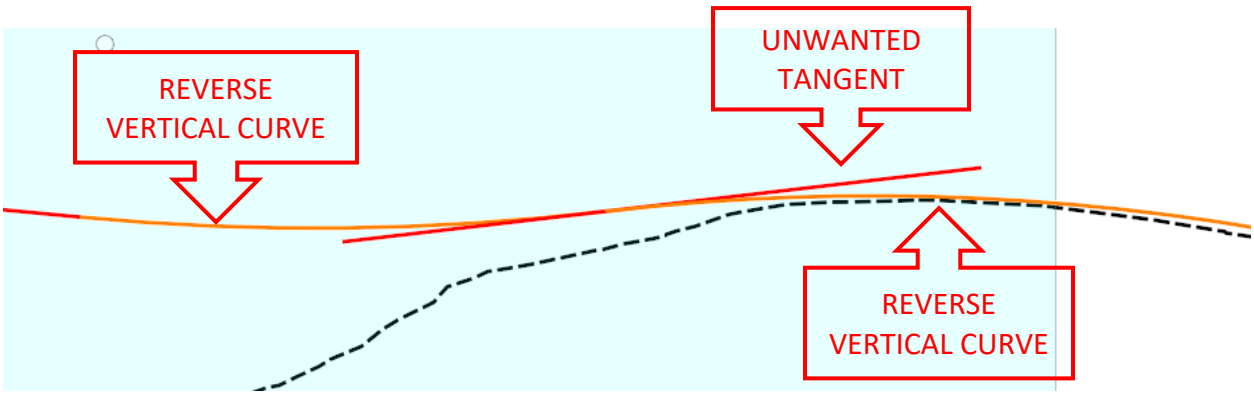


R. Set the completed profile as Active, this will automatically remove the Active setting applied to the existing ground line earlier.

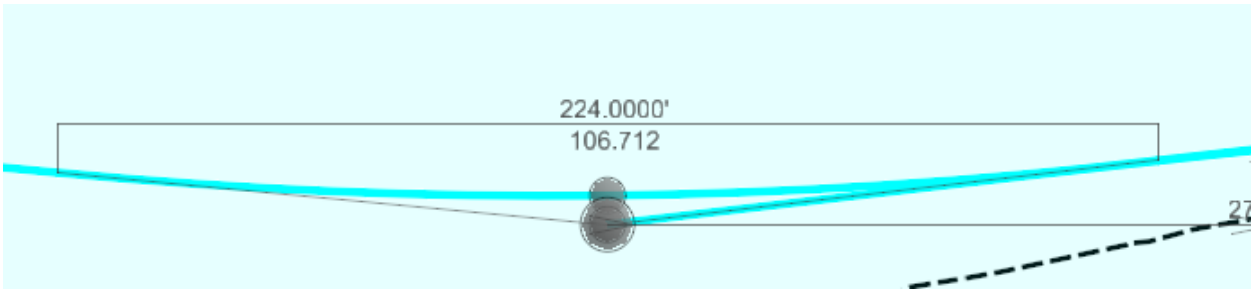


3. Correct Mistakes

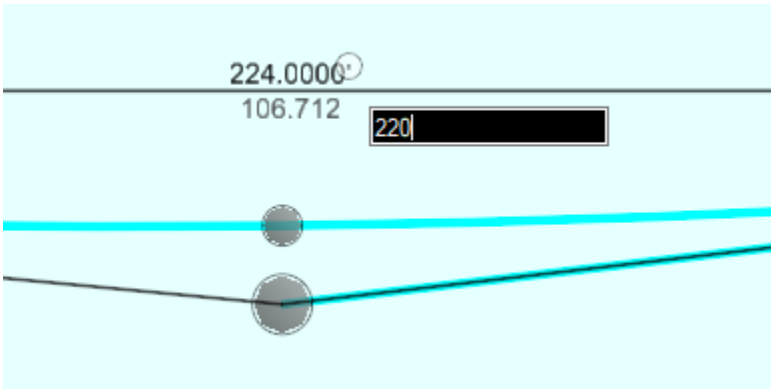
A. Note that when using this method and a reversing vertical curve is created that the tangent lines remain as part of the profile. This is because the tangent line is placed prior to placing the curve, the curve is placed one VPI behind where the profile is placed.



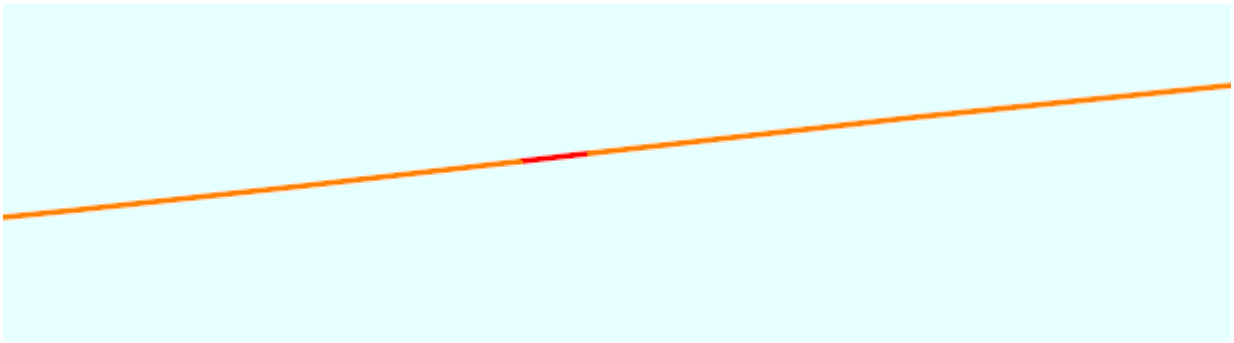
B. There is a relatively easy solution to fix this issue. Use the Element Selection tool to highlight the curve and display the Text Modifiers.



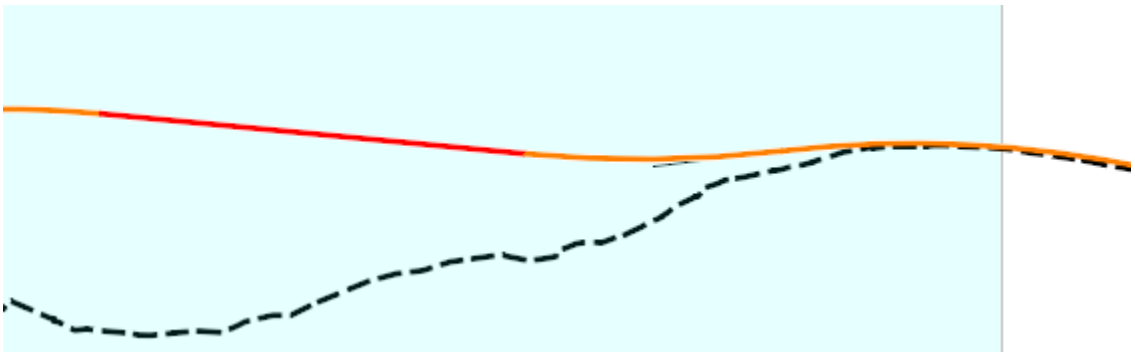
C. Edit the curve length to make the curve shorter, in this example from 224’ to 220’.



D. This will allow for a short tangent section to be created in the profile between the two curves, shown as a short red line.



E. Edit the curve length again going back to 224', this time because the curve is the last element to be defined the tangent will go away, although it will still show as a thin black line because if the curve were shortened again the tangent element would need to be displayed.



F. The reversing curves will be correctly reported as shown in the vertical geometry report, shown as PVRC.

Element: Symmetrical Parabola

VPC	2726.0000000	409.3739450
VPI	2838.0000000	408.3200000
PVRC	2950.0000000	409.6170588
VLP	2826.4182430	408.9014659
Length:	224.0000000	
Entrance Grade:	-0.009	
Exit Grade:	0.012	
r = (g2 - g1) / L:	0.9371029	
K = l / (g2 - g1):	106.7118660	
Middle Ordinate:	0.5877509	

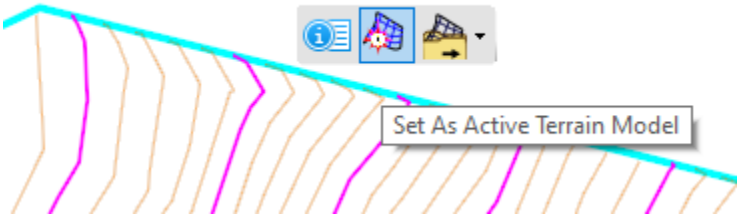
Element: Symmetrical Parabola

PVRC	2950.0000000	409.6170588
VPI	3110.0000000	411.4700000
VPT	3270.0000000	408.1085640
VHP	3063.7127520	410.2755058
Length:	320.0000000	
Entrance Grade:	0.012	
Exit Grade:	-0.021	
r = (g2 - g1) / L:	-1.0184330	
K = l / (g2 - g1):	98.1900590	
Middle Ordinate:	-1.3035943	

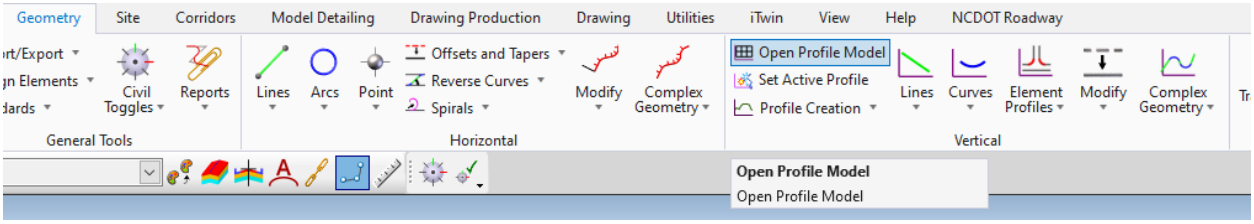
Vertical Geometry Exercise – Profile Complex By Elements

In this exercise, you will learn how to create a vertical profile by combining individual elements into a single complex element. Like the horizontal alignment the user will use the various vertical geometry tools to create lines and parabolic curves and then join those elements together into a vertical profile. This will be a common method of designing vertical alignments.

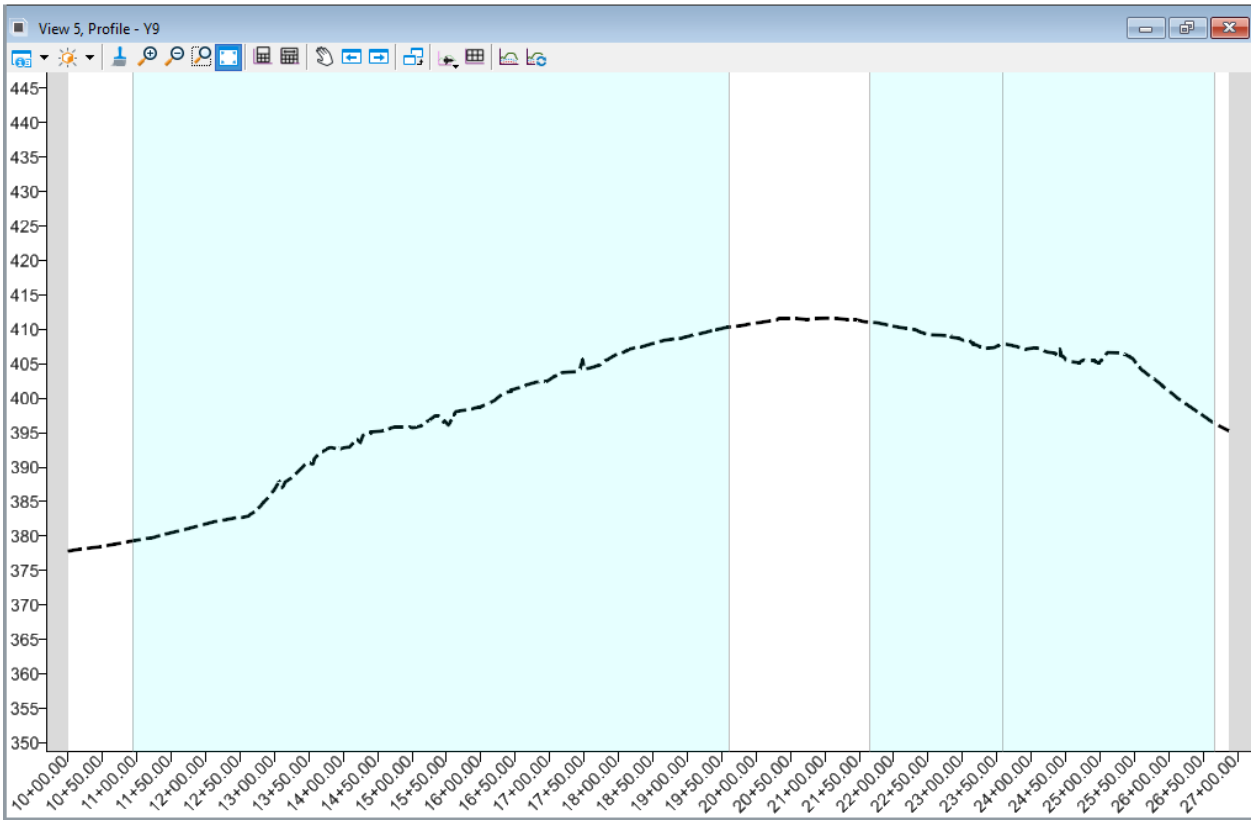
1. **Open the Profile Model View**
   A. Open the ***R-2635C_RDY_ALG_Y9.dg*** design file.
   B. Set the Existing Terrain Model as the Active Terrain Model



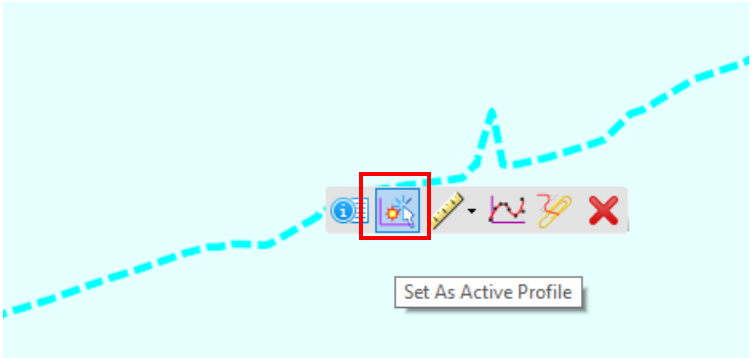
   C. Open the Profile Model View



D. The profile Mode View should display with the existing ground line shown. Note that Y9 is the alignment that intersects Y11, the profile completed in the previous section.



E. Set the existing ground profile as the Active Profile. This is like setting the existing terrain model active. Highlight the profile, move the cursor off the profile line and then back on to the line. The context menu will display, and the user can left click on the icon to set the profile as Active.



2. Profile Intersection Point

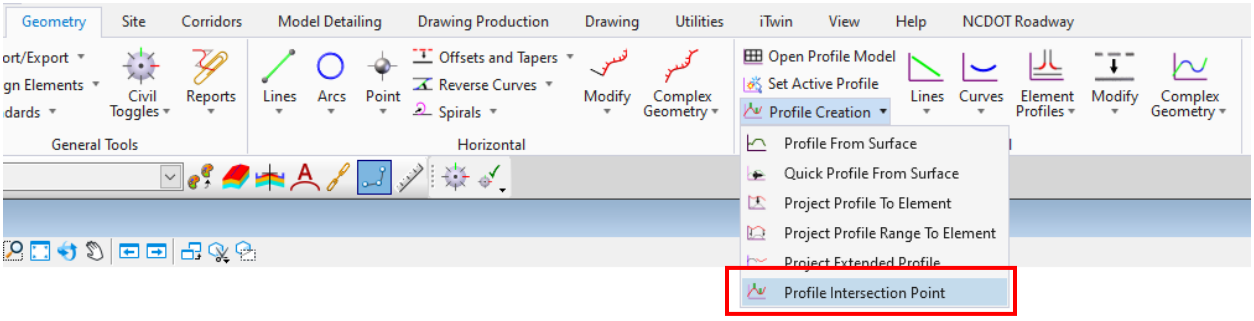
A. The Profile Intersection Point tool will locate a point in the Profile Model View and the station and elevation of two intersecting alignments. This will be a very useful tool when designing a vertical profile that intersects another roadway.

B. The alignment that is intersected by alignment being used for design must have a profile.

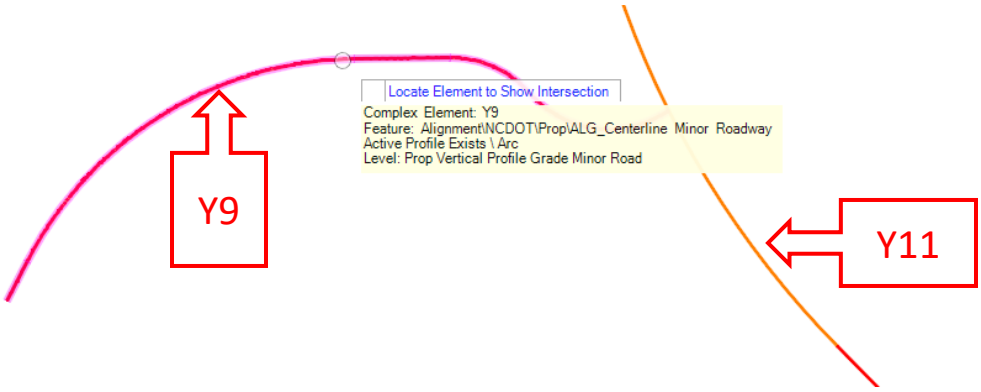
C. Neither of the alignments must be a roadway centerline alignment; either one can represent many other elements.

- It can be a centerline alignment from another ALG file. In this case the elevation will be based on whatever profile is active in the other ALG file.
- It can be an EOT alignment from a CMD file
- It can be a special ditch centerline with a profile
- Any complex element with a proposed profile will work

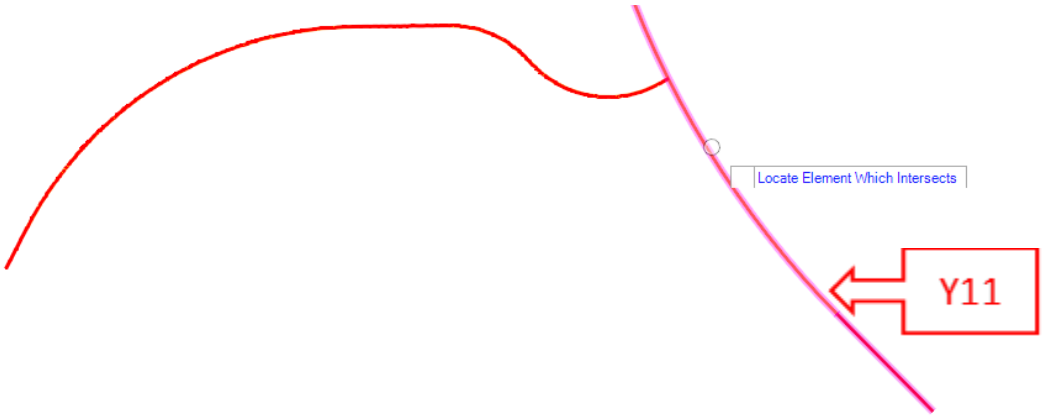
D. Start the **Profile Intersection Point** tool from the Profile Creation tool group in the *Vertical* section of the *Geometry* ribbon.



E. At the prompt left click to select the Element to Show Intersection. This is the element that is associated with the profile being designed, this will be used to determine the station of the point placed in the profile model. In this example that is the Y9 alignment.

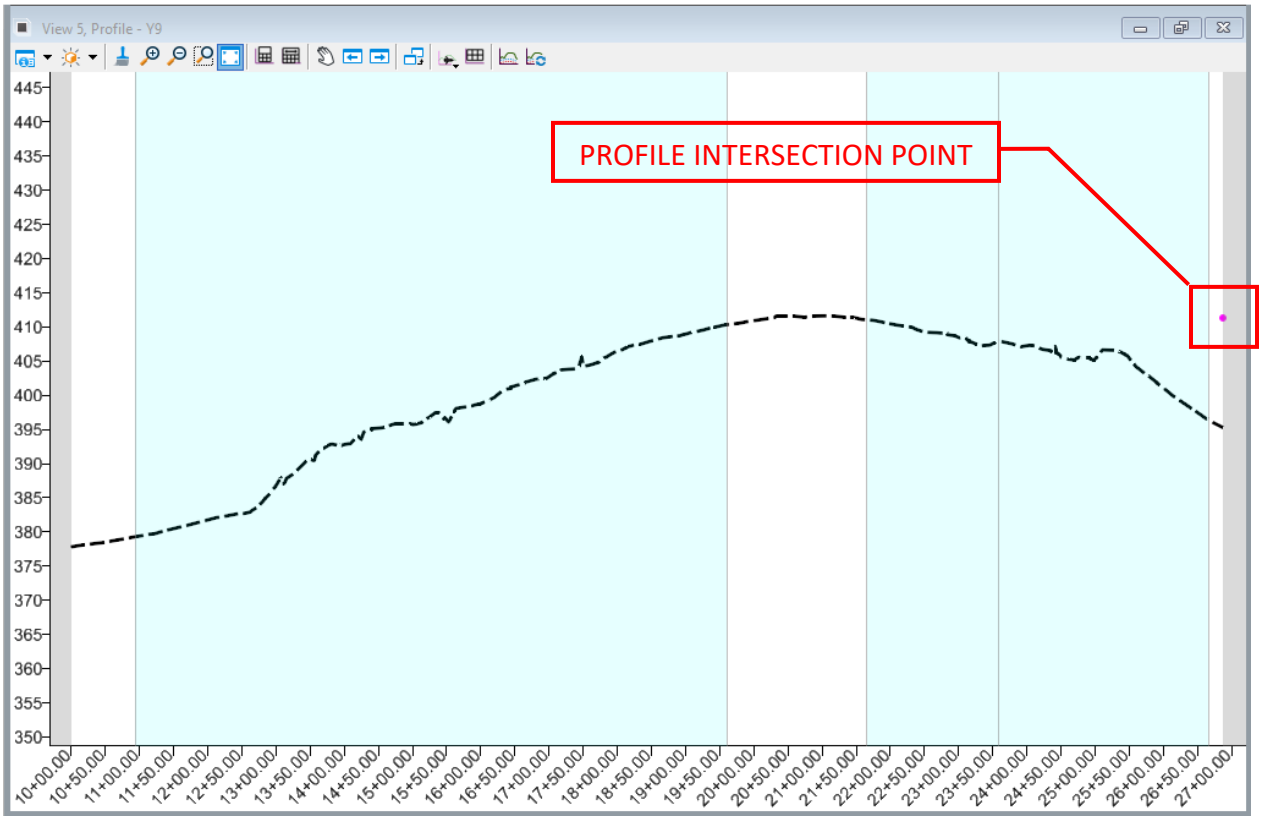


F. At the next prompt left click to Locate Element Which Intersects. This is the element with the completed profile that will be used to determine the elevation of the point placed in the profile model.



G. At the prompt right click to reset and finish the tool.

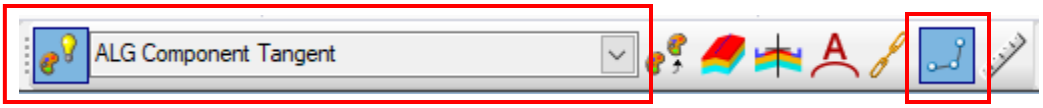
H. A point has now been placed in the profile model, the point is located on the station along Y9 where the two alignments intersected and the elevation of the Y11 profile where the two alignments intersect. Note:
   - The Y11 alignment is contained in a reference file, reference files can be used as reference elements for geometry tools
   - The elevation is based on the Active profile in the ***R-2635C_RDY_ALG_Y11.dgn*** file. Before closing the Y11 ALG file the proposed centerline profile was set Active.
   - The point placed in the Y9 Profile Model is a live reference of the Y11 ALG file. If the Y11 profile changes the elevation of the point will change. This is an important concept to remember because ORD can maintain design intent it is possible that a change to the Y11 profile can automatically cause a revision to the Y9 profile. The designer must consider this when choosing how to construct the Y9 profile.



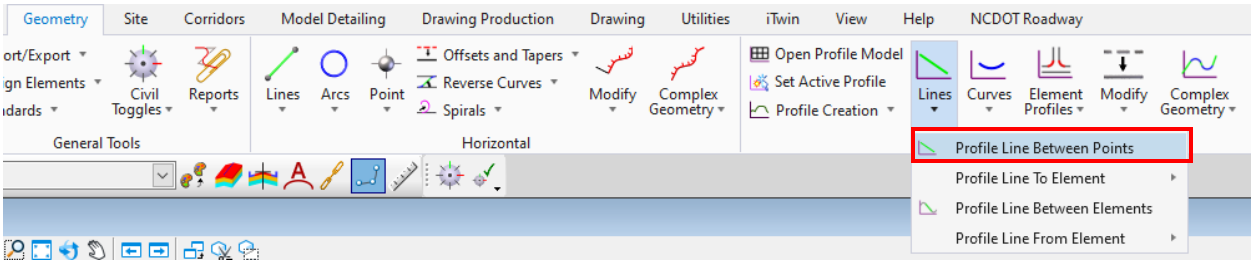
3. Profile Elements - Tangents

A. We will begin building the profile by starting with the tangent hat connects to the Y11 pgl line, the Profile Intersection Point placed in the Profile Model.

B. Set the feature definition to ALG Component Tangent, this will display the elements with different symbology that will be updated when the elements are combined into a Complex vertical Profile. Also, set Persist Snaps to ON.

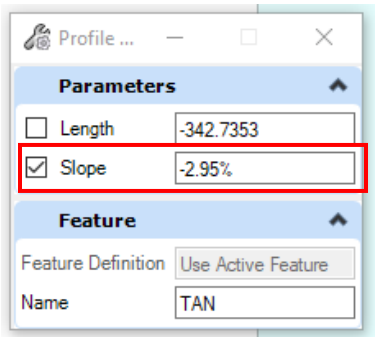


C. Start the **Profile Line Between Points** tool from the Lines tool group in the *Vertical* Section of the *Geometry* ribbon.

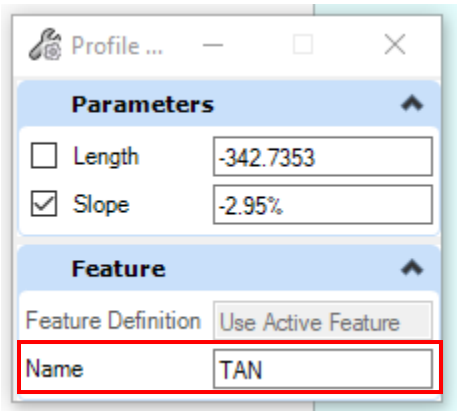


D. At the dialog prompt set the slope to -2.95%, this is the cross slope of Y11 calculated based on the skew of the intersecting alignments. This tangent could be placed using alternate methods as well.

- If the corridor for Y11 had been completed an additional Profile Intersection Point could have been placed at the edge of pavement of the proposed corridor.
- Civil AccuDraw could have been utilized based on a calculated intersection station and elevation.

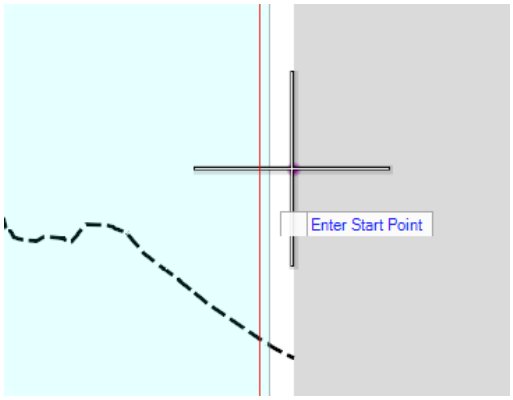


E. Note that the name of the element has been auto filled as TAN, this is based on the selected Feature Definition.

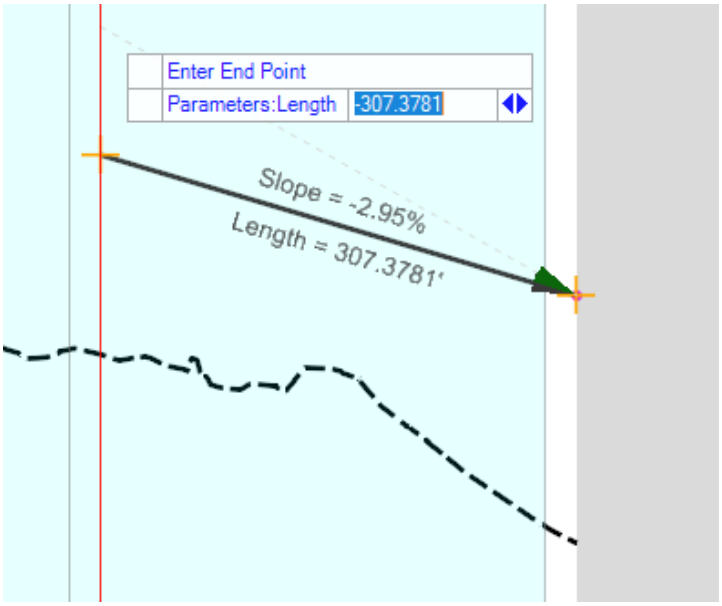


F. At the prompt left click anywhere in the Profile model window to locate the Profile model view.

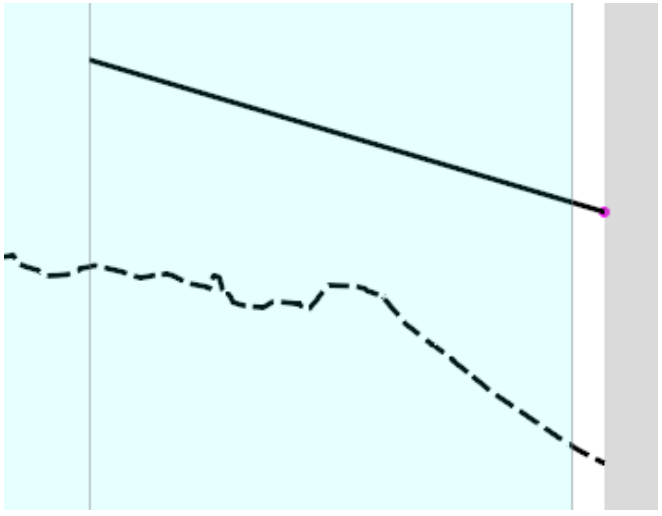
G. Snap to the previously place Profile Intersection Point and left click to locate the start point.



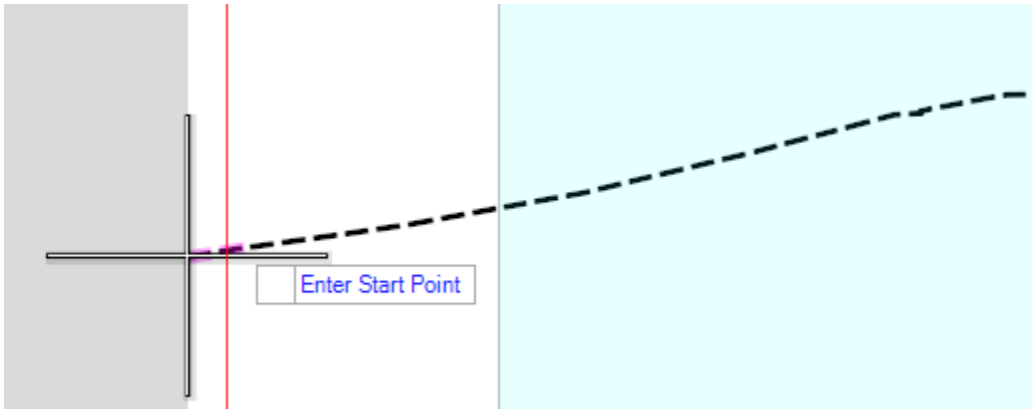
H. Left click to dynamically set the Length and End Point. This will be trimmed later when additional elements are placed. Note the -2.95% slope was required because the slope is calculated in the direction of the stationing.



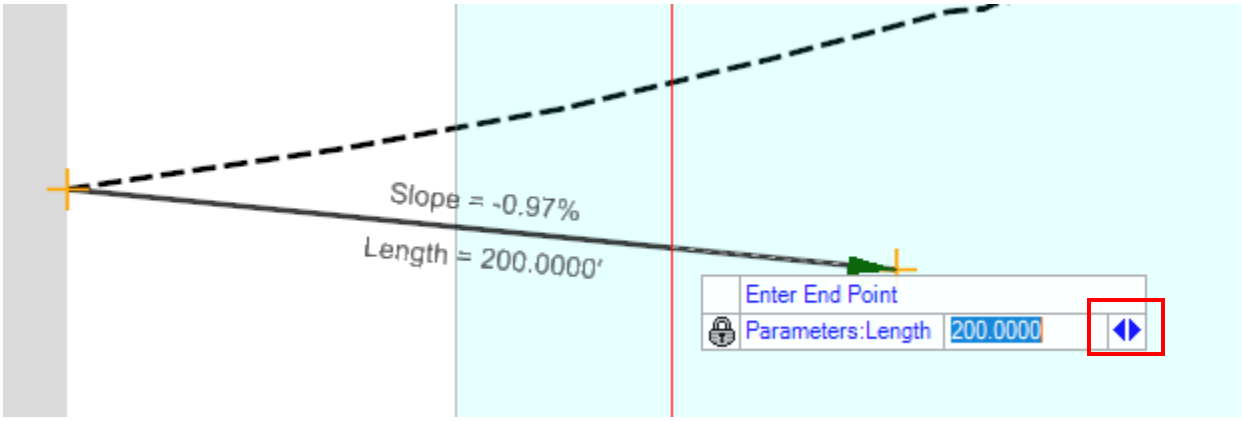
I. This will complete the tool and place the line. Because the Persist Snap rule is on and because when placing the line, we snapped to the Profile Intersection Point any updates to the Y11 profile will cause the elevation of the tie point to change, the slope of -2.95% will be maintained.



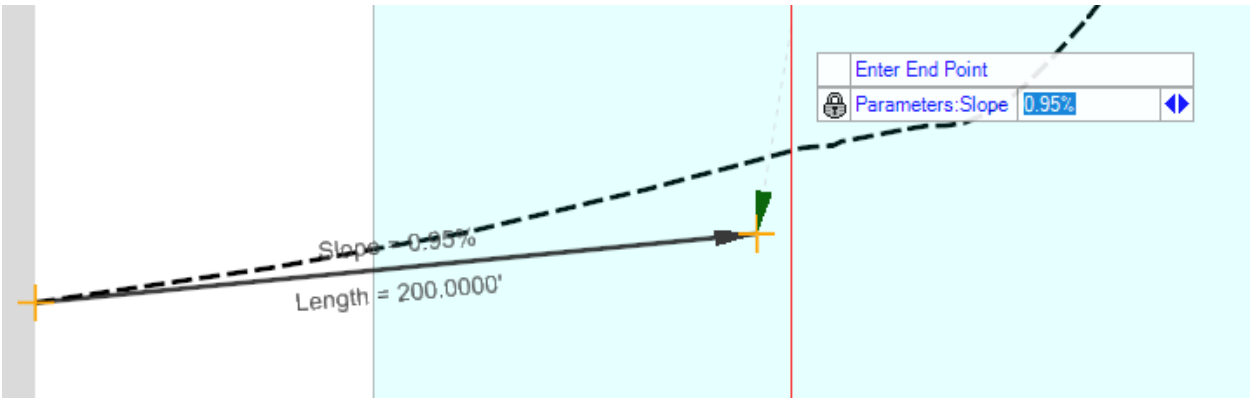
J. The Profile Line Between Points tool will automatically restart. To place the beginning tangent, we want to start the profile at the existing ground at Station 10+00.00. To do this Snap to the existing ground line at the beginning of the profile and left click to accept the starting point.



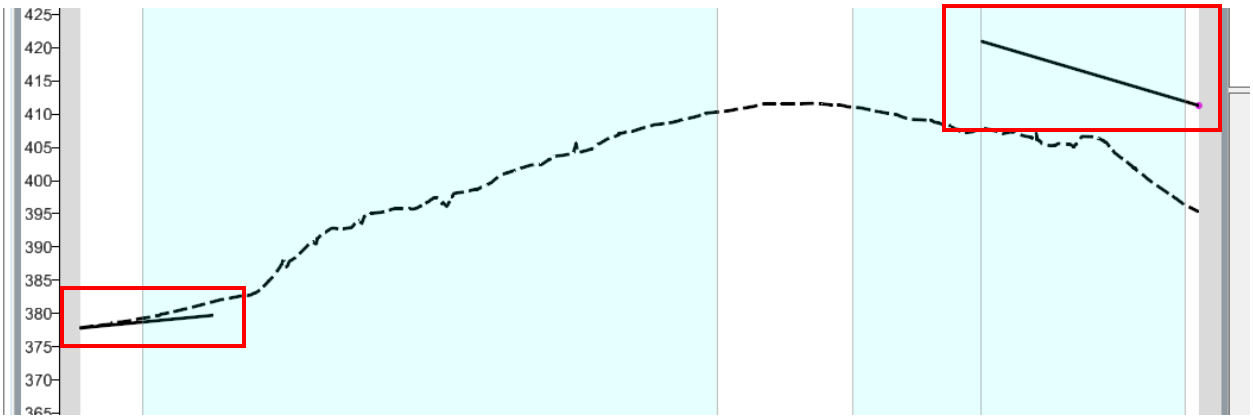
K. At the prompt enter 200.00’ for the Length and ENTER to lock. Note the blue arrows to the right of the length indicating additional inputs available. These inputs can be accessed by using the LEFT and RIGHT Arrow keys.



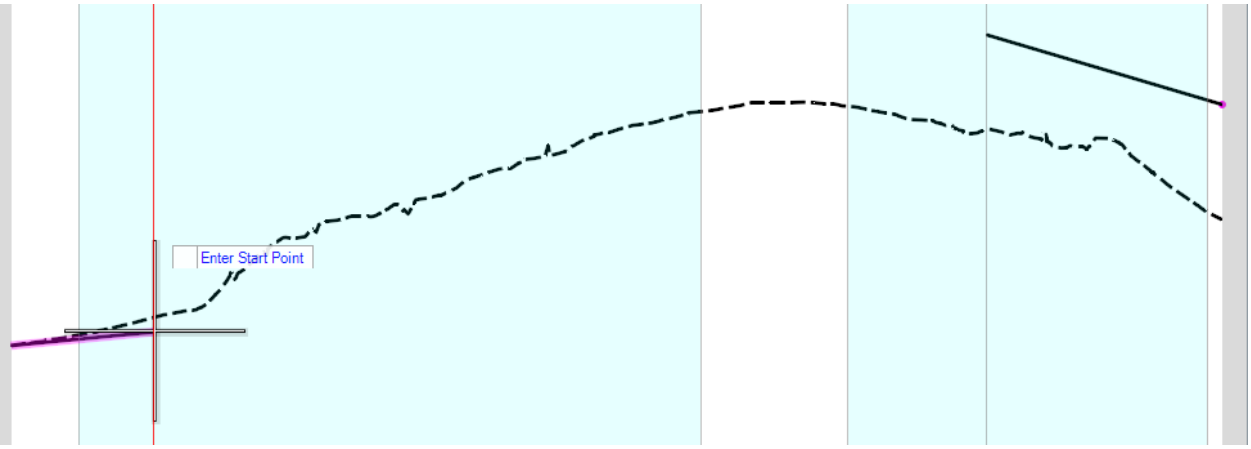
L. Use the RIGHT Arrow key to change the heads-up prompt to the Slope Parameter and enter 0.95%.



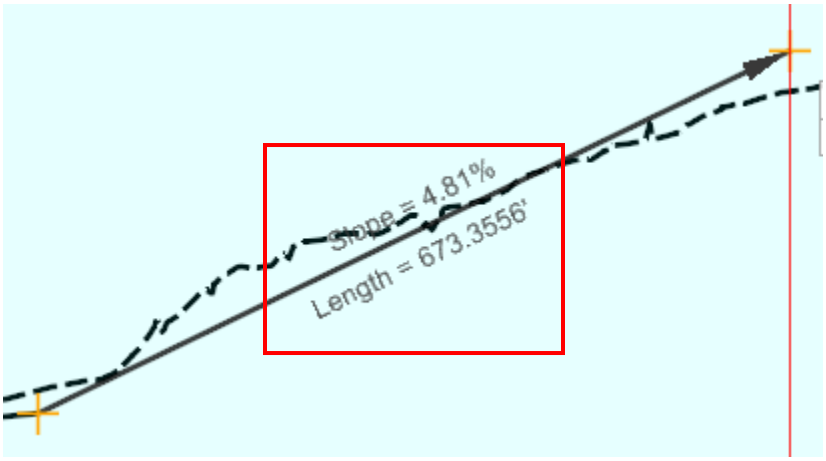
M. Left click to accept and place the tangent. The profile should now have a beginning and ending tangent.



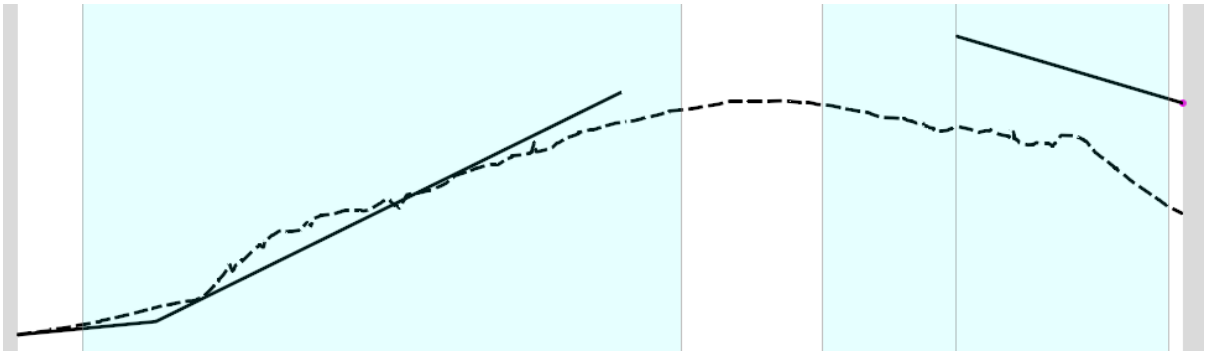
N. Using the **Profile Line Between Points** tool snap to the end of the beginning tangent to create the next tangent section.



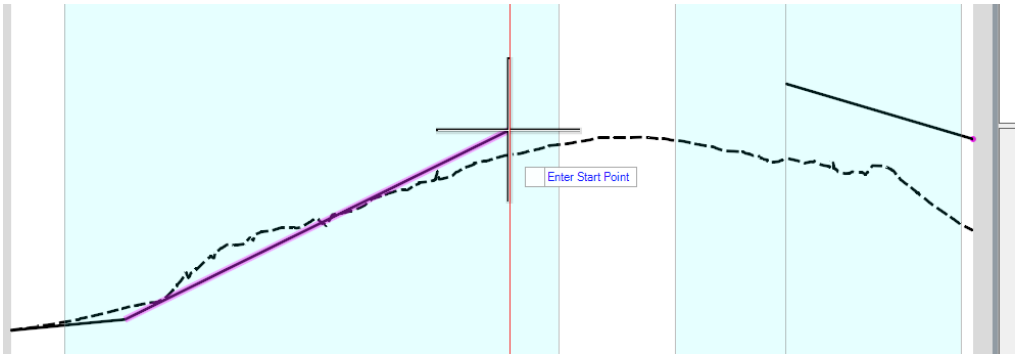
O. Use the dynamic display to place a tangent that is approximately 675’ long and at a 5.00% grade. The exact location of the VPI will be revised prior to creating the complex element.



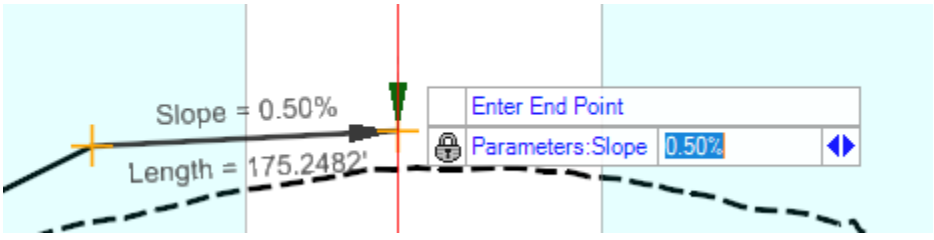
P. Left click to accept the end point and place the line.



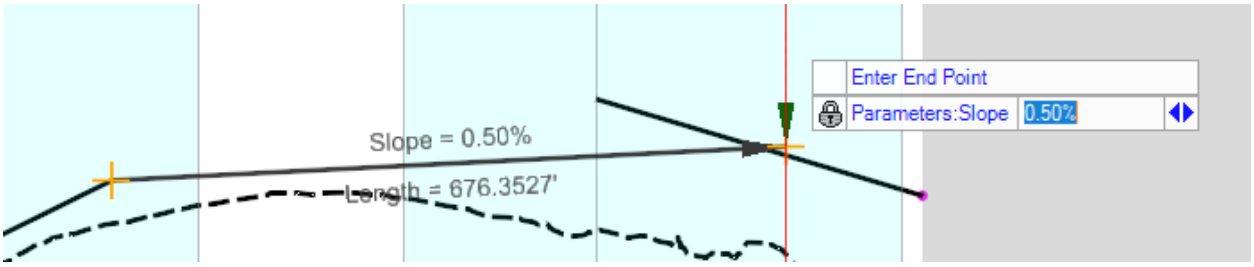
Q. Using the **Profile Line Between Points** tool snap to the end of the newly placed tangent to create the next tangent section.



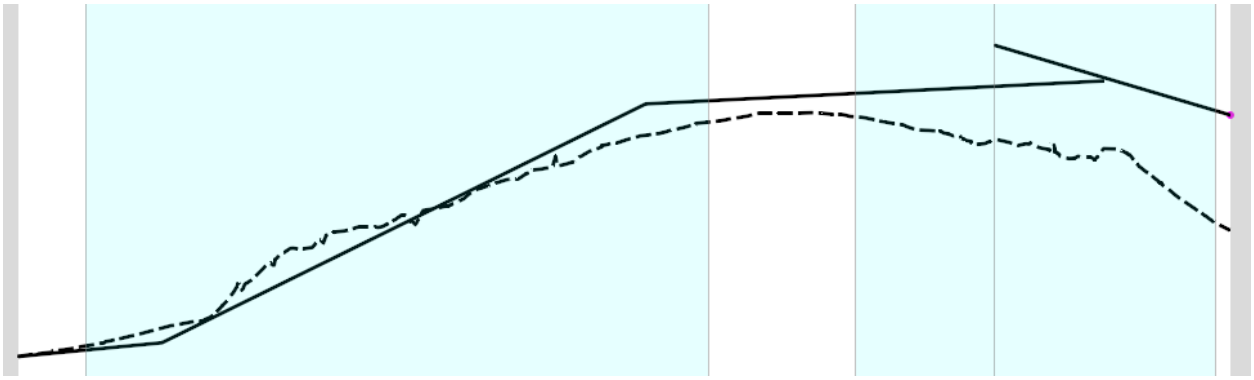
R. Use the LEFT Arrow key to toggle to the Parameters Slope input and enter 0.50% to lock the slope of the tangent line



S. Extend the line close to the final tangent and left click to accept the end point and place the line. The exact length is not important.



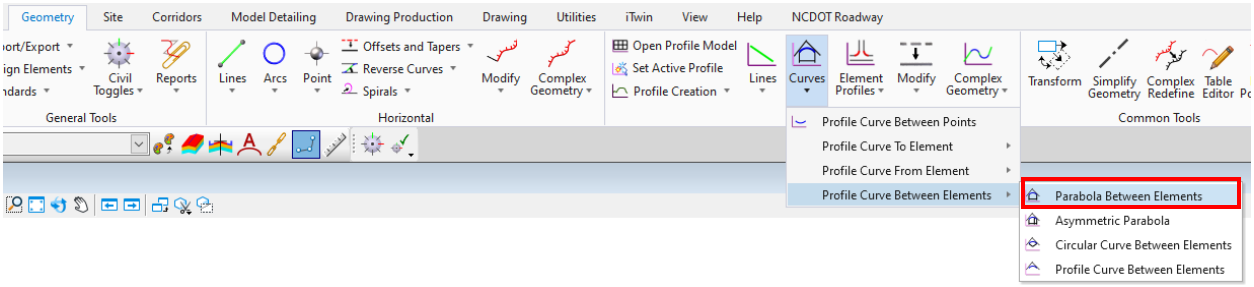
T. All of the tangents for the proposed profile have now been created.



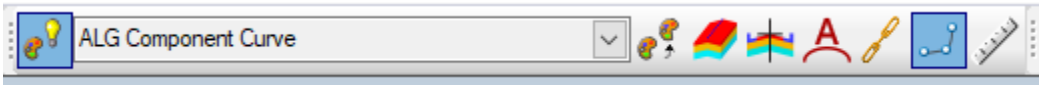
4. Profile Elements – Curves

A. There are many ways the user can add curves to the profile, the most common method when all the tangents are known will likely be the **Parabola Between Elements** tool.

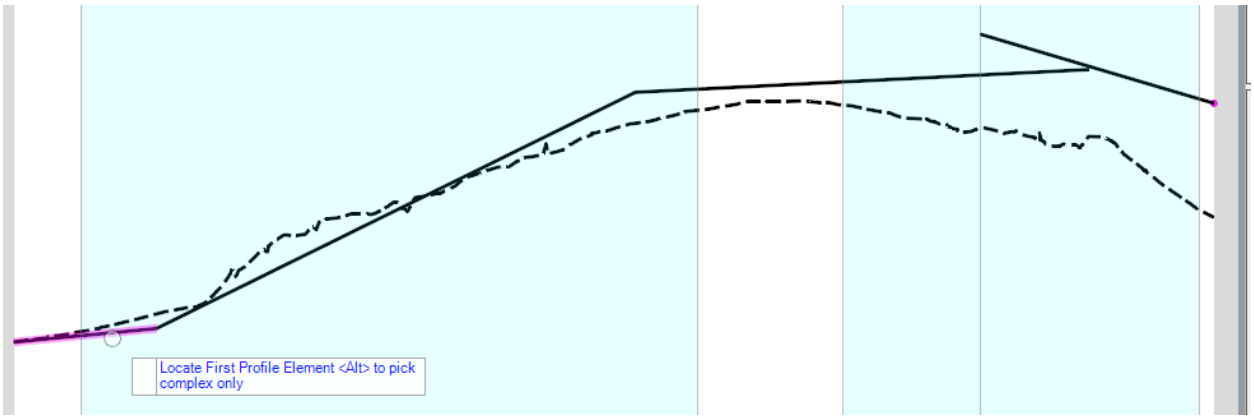
B. The **Parabola Between Elements** tool is under the Profile Curve Between Elements tool group located in the *Vertical* section of the *Geometry* ribbon.



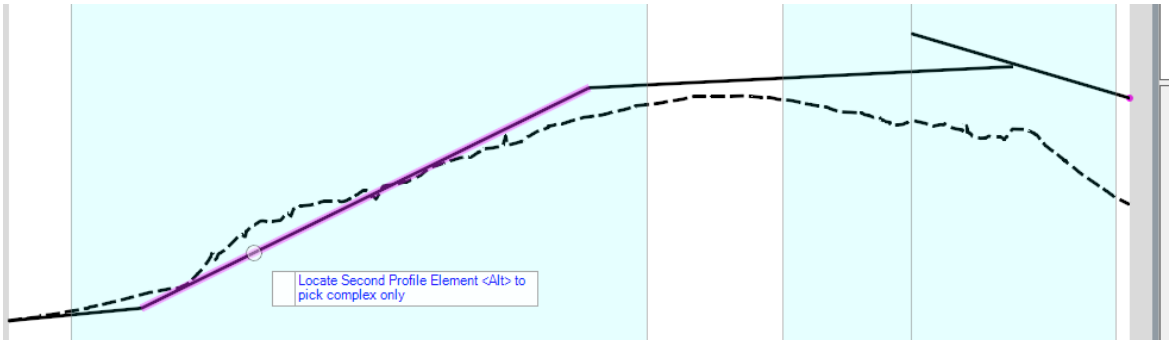
C. Set the Feature Definition to ALG Component Curve



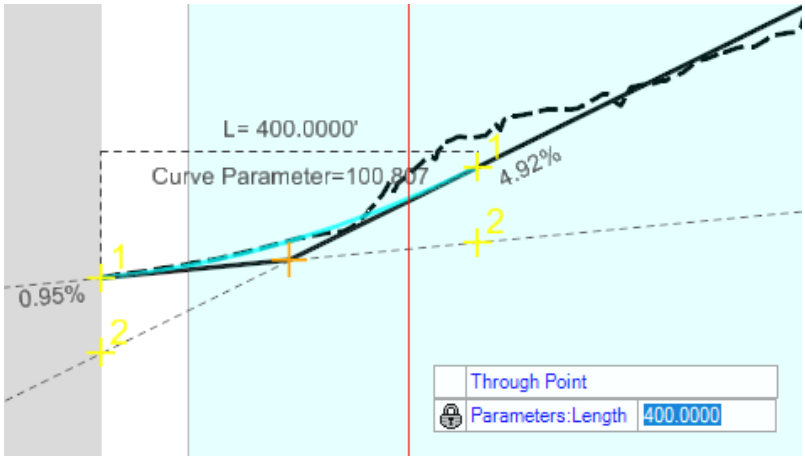
D. At the prompt Left click to locate the beginning tangent.



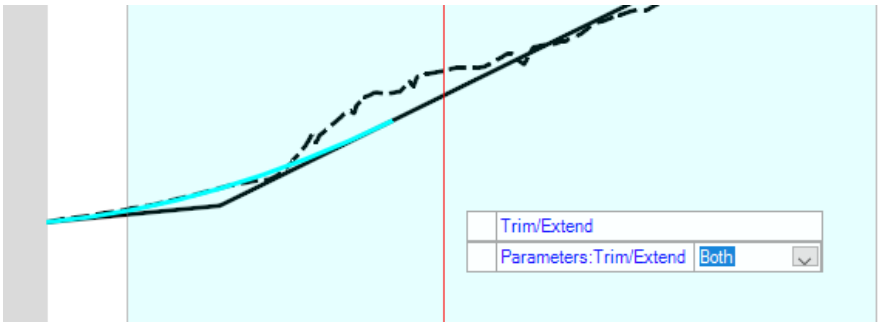
E. Left click to locate the next tangent.



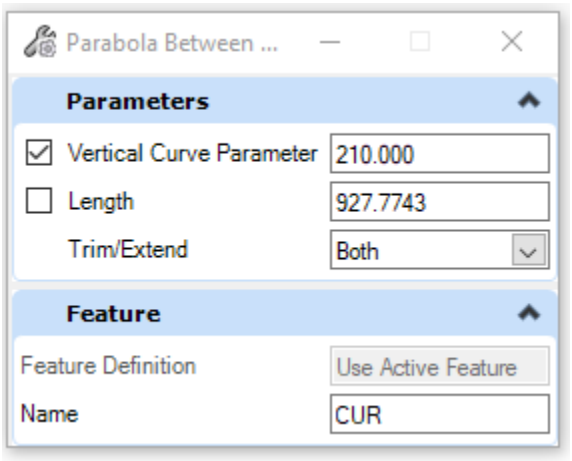
F. At the heads-up prompt enter the Parameter Length as 400.00', position the cursor so a SAG curve is constructed.



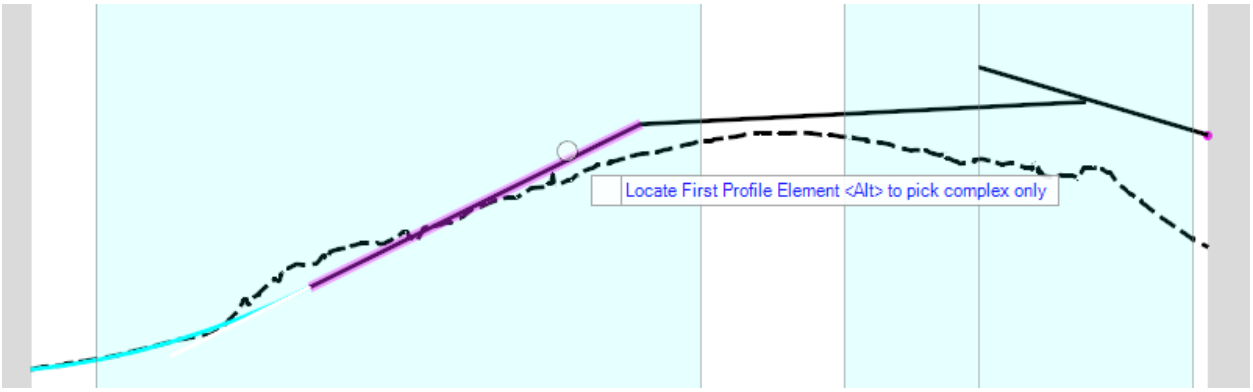
G. Use the UP or DOWN arrow keys to toggle to the Trim option of Both and left click to accept and place the curve. Note that due to the new feature definition the symbology of the vertical curve is different than the symbology of the tangent.



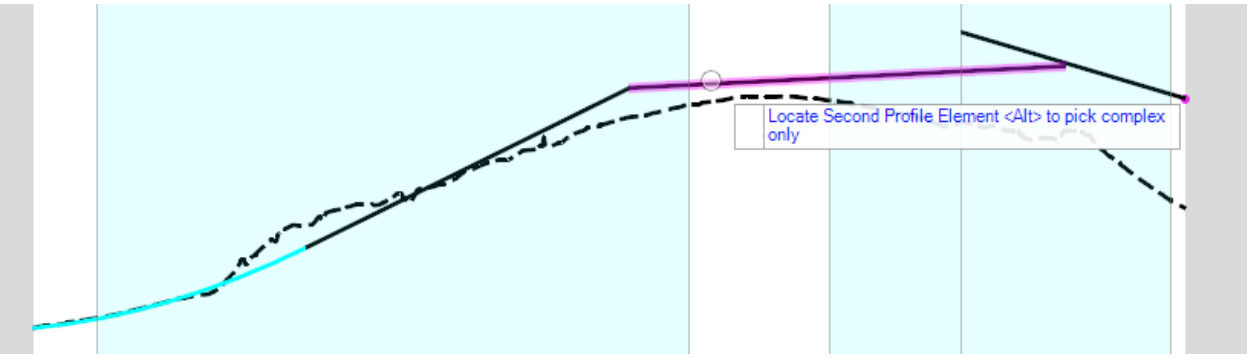
H. The Parabola Between Elements will automatically restart. Find the dialog box and set the vertical curve parameter to 210.00. This is the desired K Value for the curve. The length will automatically be set based on this value.



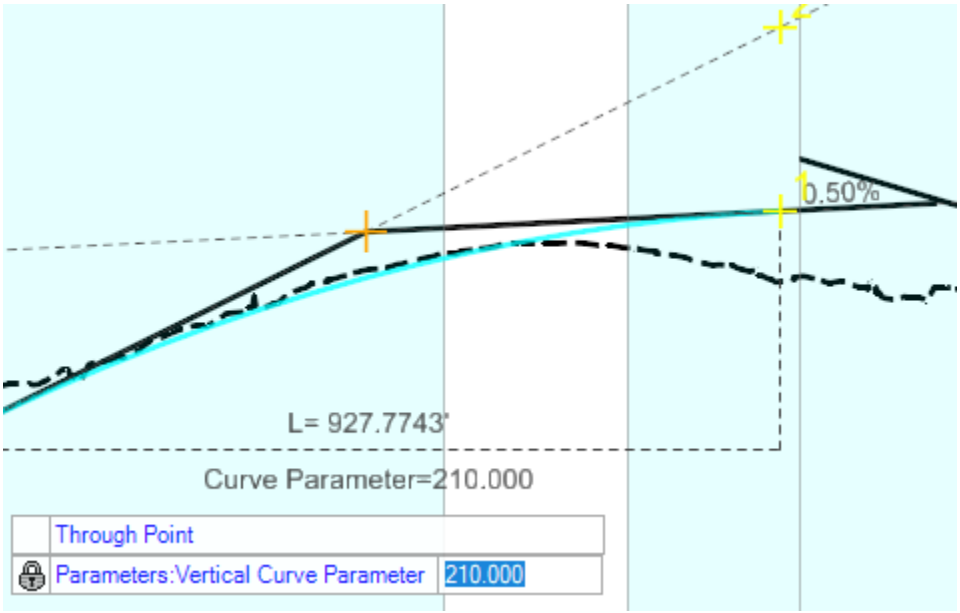
I. Left click to locate the next tangent.



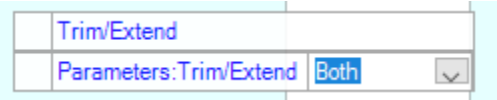
J. Left click to locate the ahead tangent.



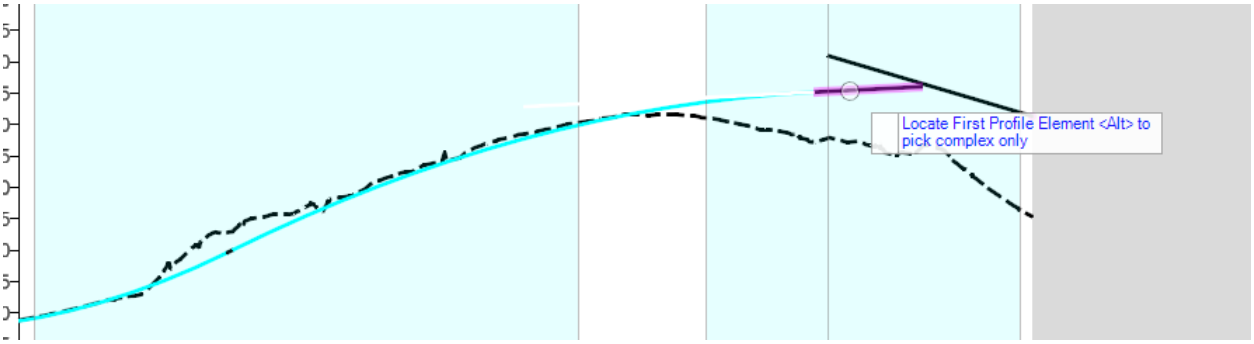
K. Position the mouse so that a crest vertical curve is created. Left click to accept and place a curve with a K Value of 210.



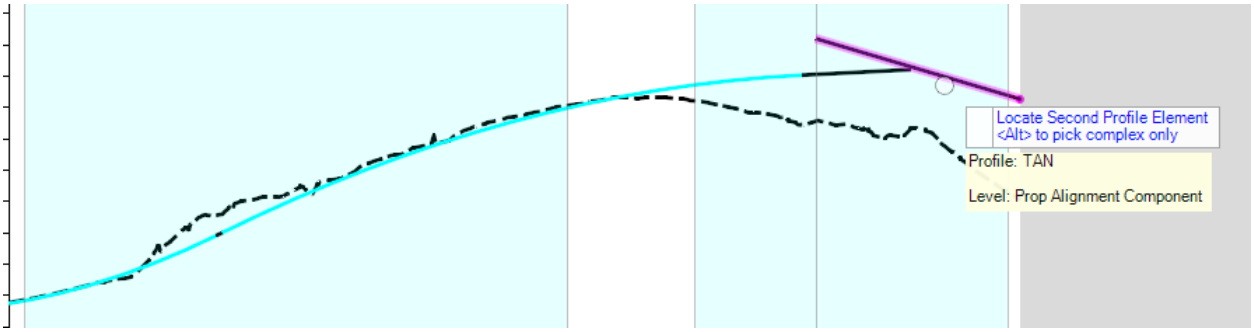
L. Left click to accept the Trim option of Both.



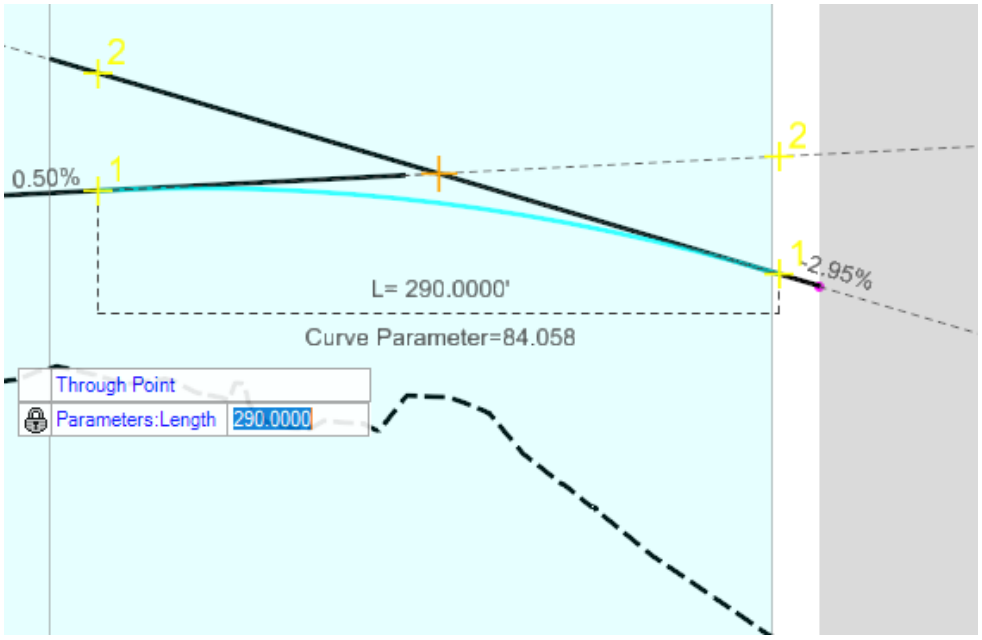
M. The Parabola Between Elements tool will restart at the completion of the previous curve. Left click to accept the back tangent.



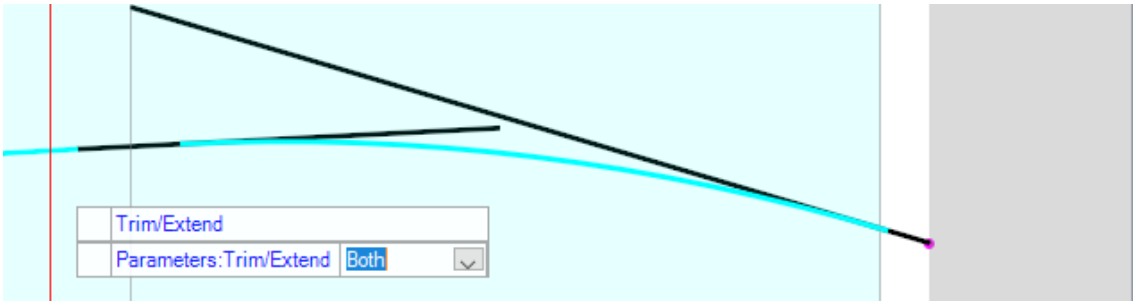
N. Left click to accept the final tangent.



O. At the heads-up prompt enter 290.00’ for the curve length.



P. Position the cursor to create a crest vertical curve and left click to accept and place the curve. Left click to accept the Trim option of Both.

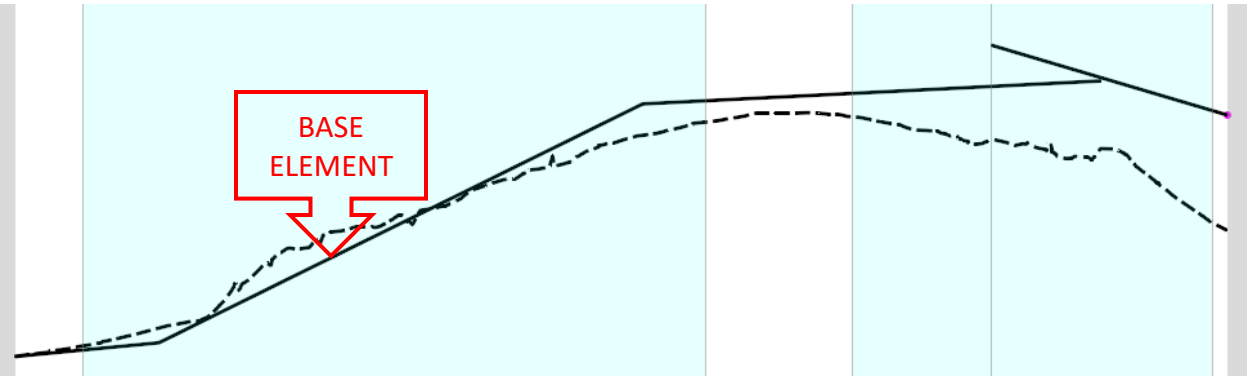


Q. This completes the placement of all the profile elements required for the completed complex vertical profile.

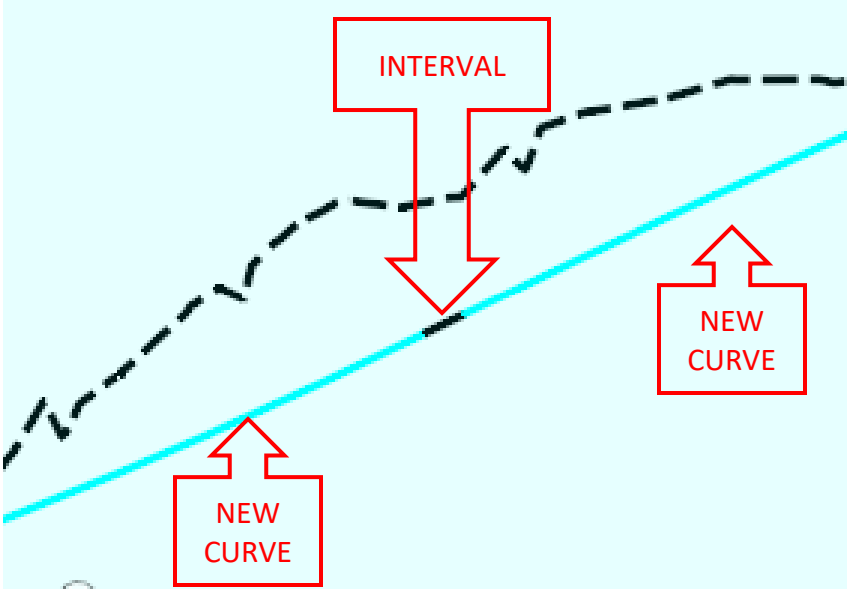
5. Refining Profile Design

A. At this point it may be desirable to refine the profile design by adjusting any curve lengths or VPI Stations and Elevations to achieve more desirable results.

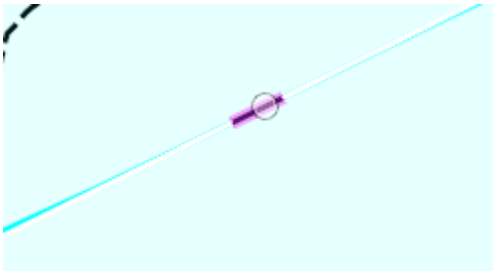
B. Use the Element Selection tool to select the second tangent element. Even though the element was trimmed to meet the curves the original tangent remains, this is called a base element. This element still exists even though it is no longer displayed.



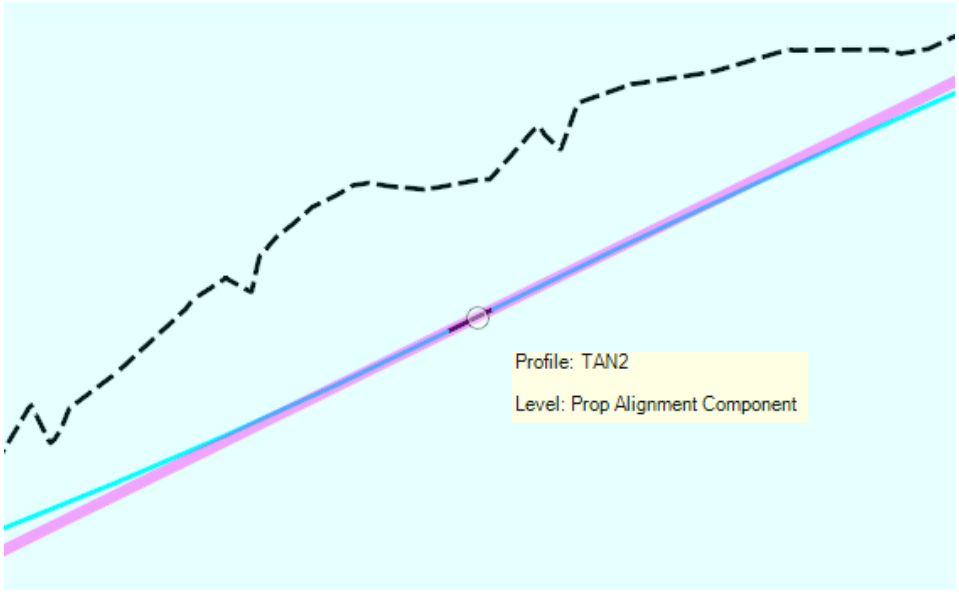
C. The new segment that is displayed after the curves are placed is called an interval. This is combination of the tangent and the curves and the rules that were used during the design process.



D. To make edits using the text manipulators the original element needs to be selected. This can be done in one of two ways
E. The first way to select an interval
   - Move the cursor onto the interval

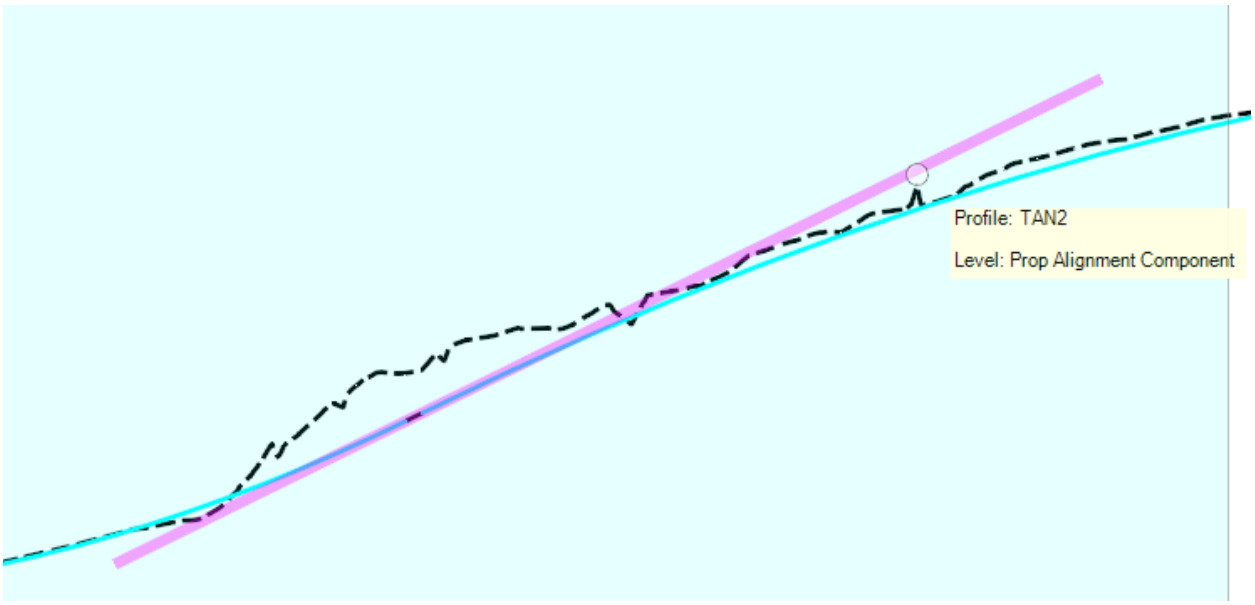


   - Right click to change the selection to the base element.



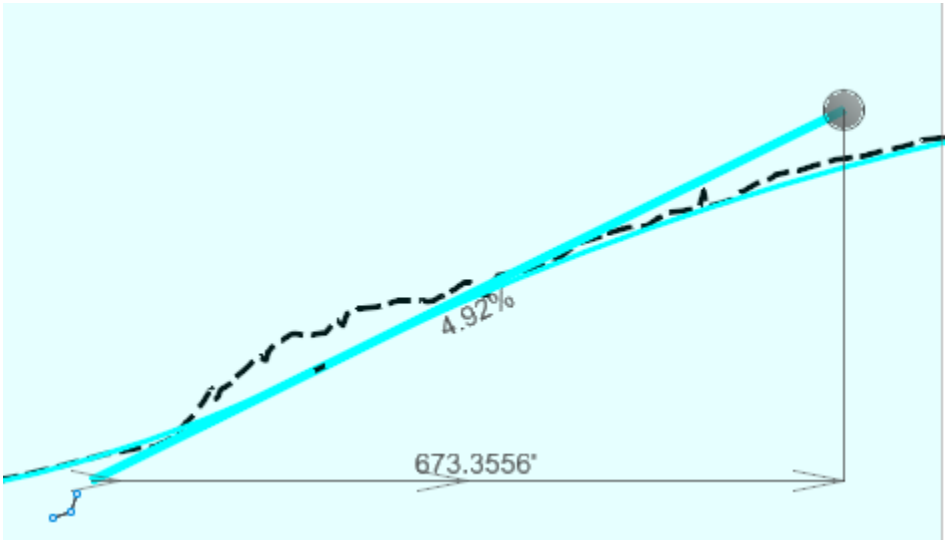
   - Left click to select the base element.

F. The second way to select a base element.
   - Move the cursor to an area along the projected interval where the base element exists, even though it is not displayed.

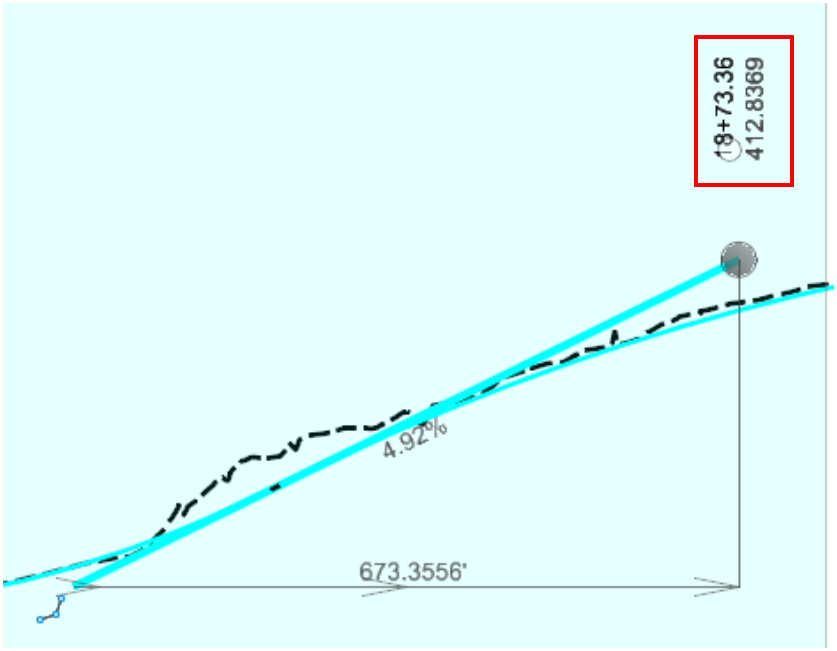


   - Left click to select the base element

G. Left click to pick the base element

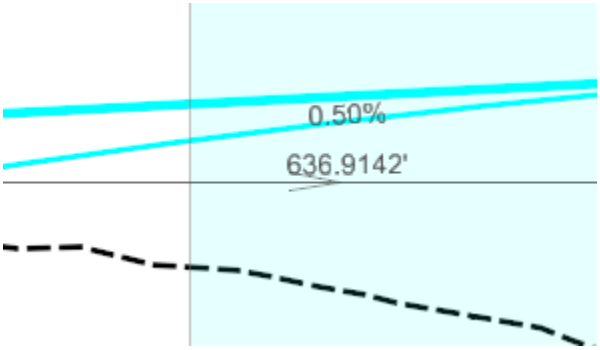


H. Move the cursor the end of the tangent where the circle is located to activate the text manipulators for the VPI Station and Elevation.

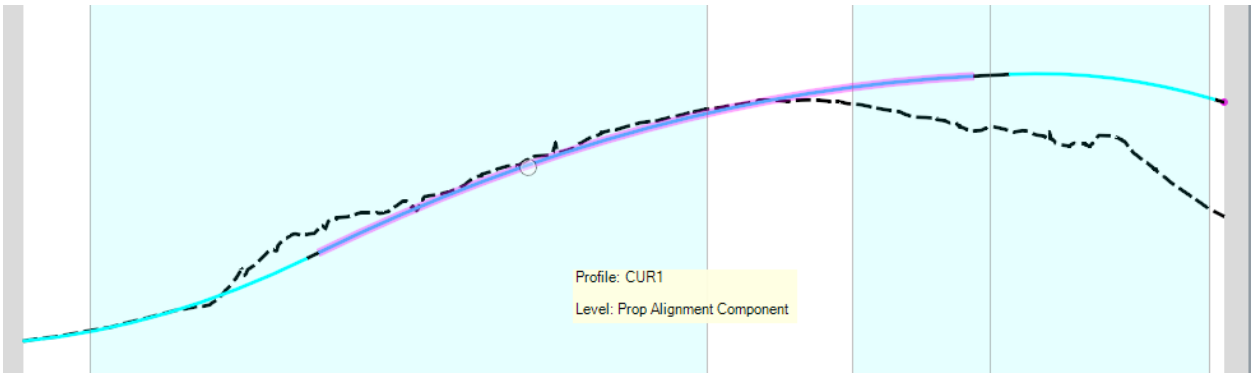


I. Update the VPI station and elevation using the text manipulators
   - Station = 18+75
   - Elevation = 412.65’

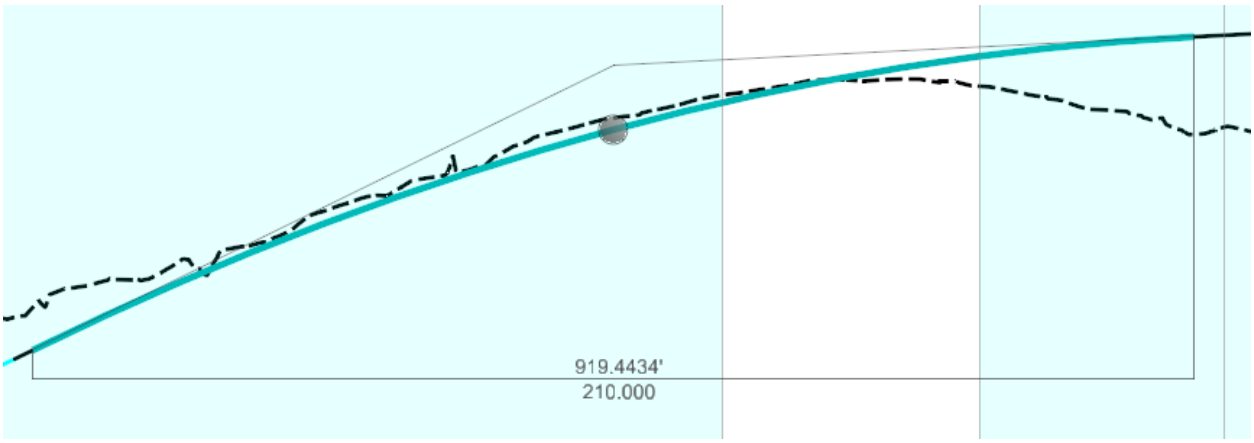
J. Note that because a snap constraint was used to create the tangent ahead of this VPI at a slope of 0.50% that when the VPI was update the ahead tangent also change to maintain the 0.50% slope.



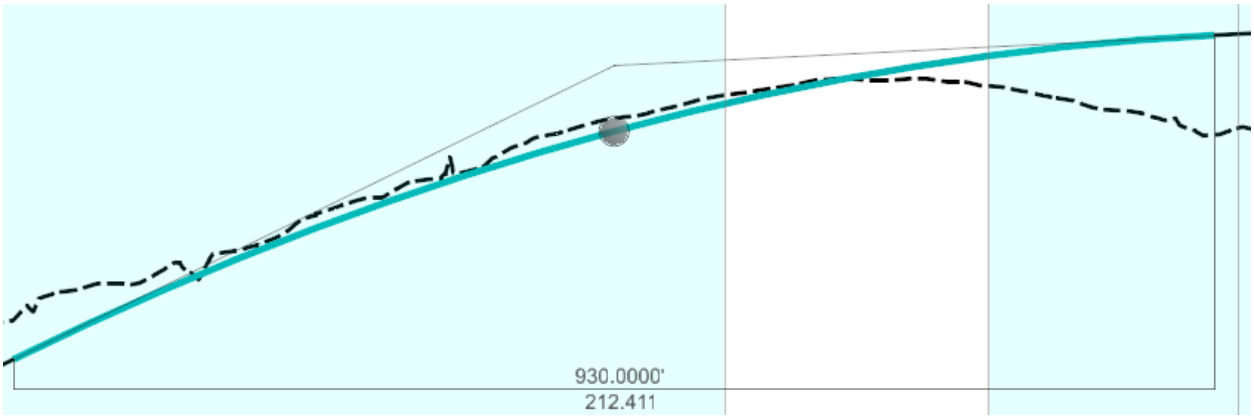
K. Use the element selection tool to select the curve at VPI 18+75



L. This curve was placed with the Vertical Curve Parameter method and a K Value of 210. This results in a length of 919.44’



M. Edit the text manipulator to change this length to 930', this will update the K value to 212.

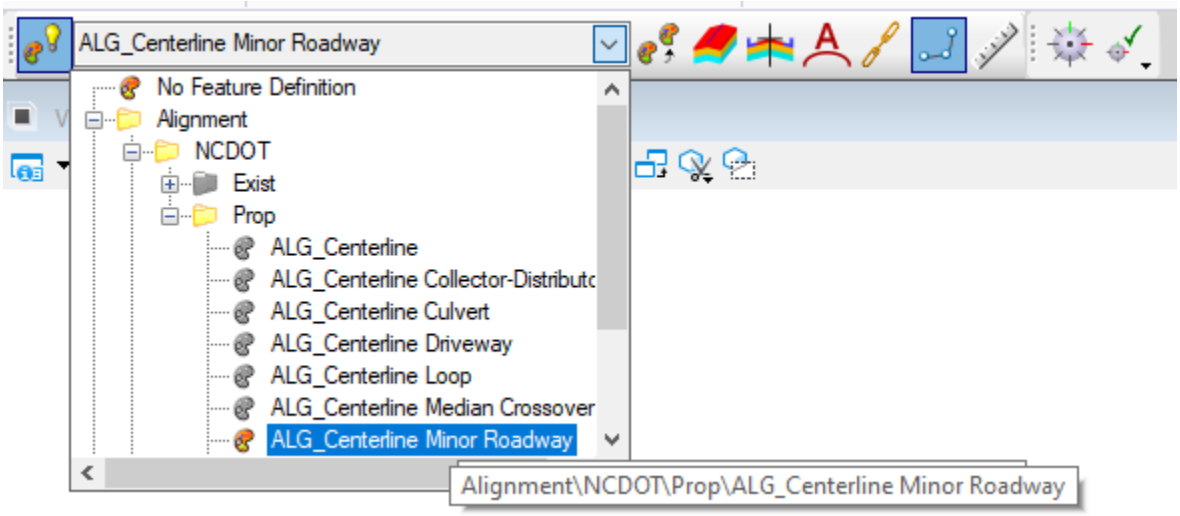


N. This completes the minor revisions to the profile elements.

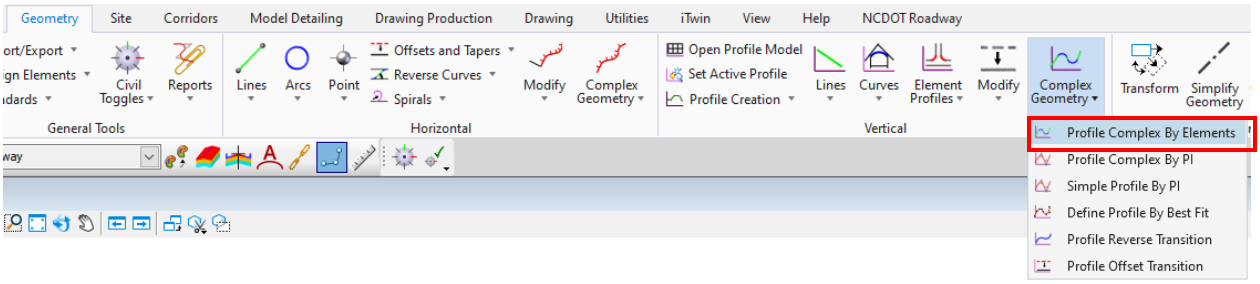
6. Creating a Complex Element

A. The final step is to join the elements together into a single complex element that will be the finished profile.

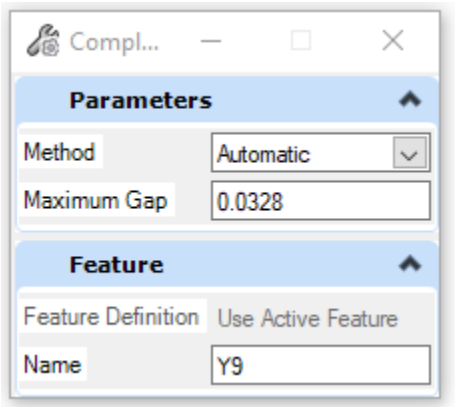
B. Change the Feature Definition to ALG_Centerline Minor Roadway, this should match the Feature Definition used to create the horizontal alignment.



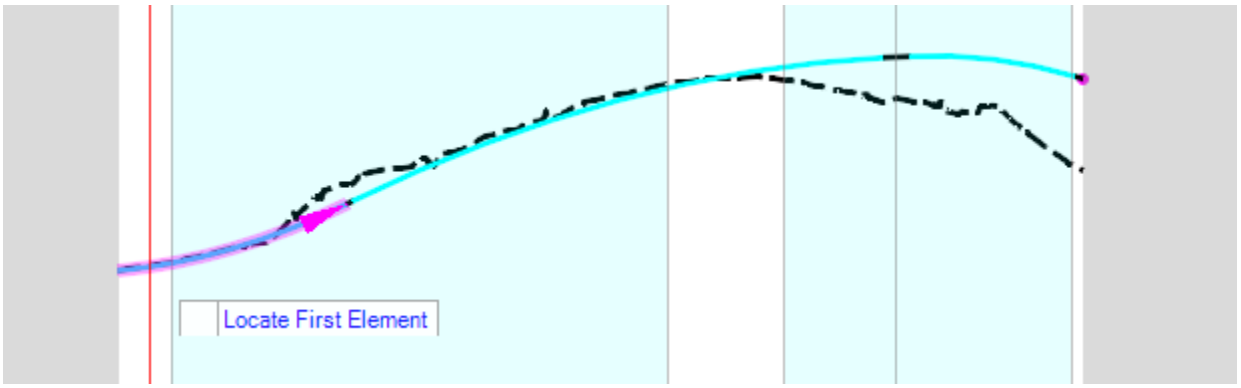
C. Select the **Profile Complex By Elements** tool from the Complex Geometry tool group located in the *Vertical* Section of the *Geometry* ribbon.



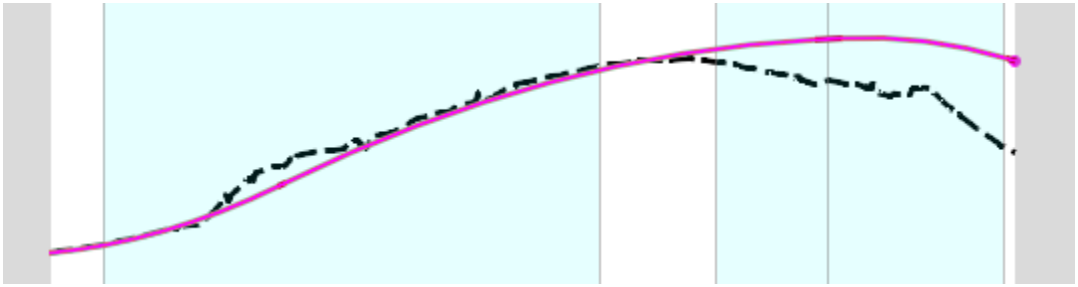
D. The dialog box will appear. Set the parameters to match the following
- Method = Automatic
  1. Automatic will automatically join all the connected elements that are within the specified maximum Gap Tolerance
  2. Manual will allow the user to select individual elements
- Maximum Gap = Leave as default value
  1. This is the maximum gap between the ends of two adjacent elements that can occur, and the element still be joined using the tool. Any elements that do not join within the default Maximum Gap value should be evaluated and redesigned to connect correctly.
- Name = Y11
  1. This name should match the alignment name for roadway profiles, this will be the name of the profile. For other profiles, the name should indicate what the profile represents. Remember that a single horizontal alignment can have multiple vertical alignments.



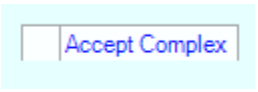
E. Left click to locate the first element in the proposed profile.



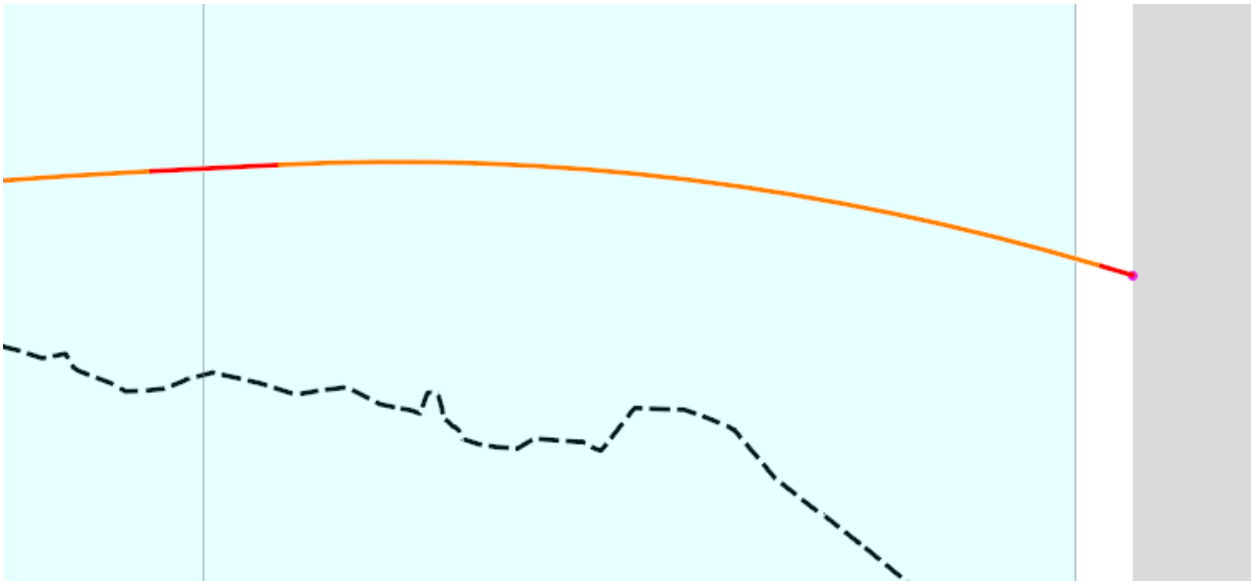
F. The tool will highlight all the connected elements



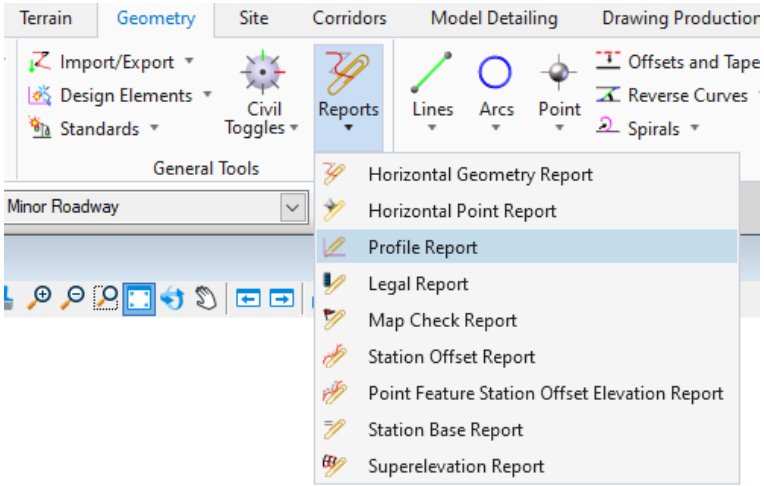
G. Left click in the Profile Model view to accept the complex element.



H. This will finish the tool and complex the complex element, completing the proposed vertical profile. Note that because the ALG_Centerline Minor Roadway Feature Definition was selected that the symbology of the profile updated. The tangent lines are now Red, and the curves are Orange.



I. There is no annotation at this stage, that will be added during the sheeting process. The profile can be reviewed by selecting the **Profile Report** tool from the Reports tool group in the *General Tools* section of the *Geometry* ribbon.



J. Note that the report indicates the name of the profile and the associated horizontal alignment. It is important to remember that each profile can only be associated with a single horizontal alignment.

Project: Default
Description:
File Name: C:\NCDOT Training\Roadway\Module 4 Vertical Alignment\R-2635C\Roadway\Alignment\R-2635C_RDY_ALG_Y9.dgn
Last Revised: 6/3/2021 16:00:08

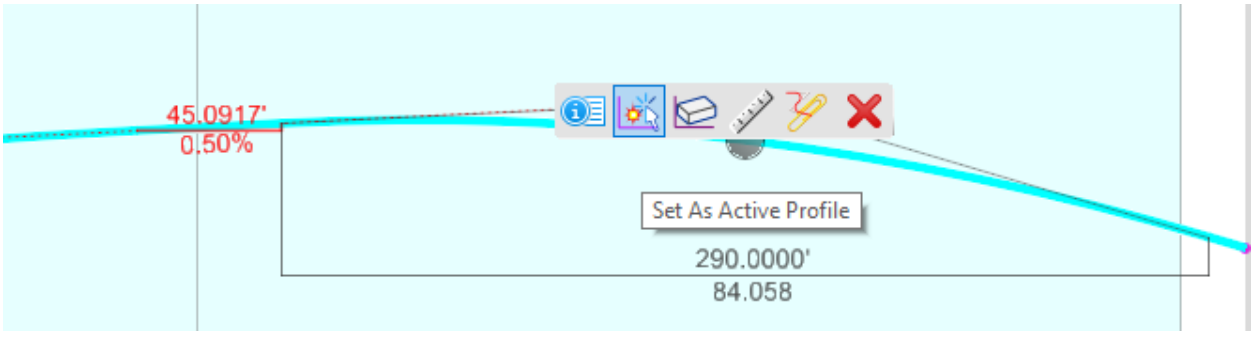
Note: All units in this report are in feet unless specified otherwise.

Horizontal Alignment: Y9
Horizontal Description:
Horizontal Style: Alignment\NCDOT\Prop\ALG_Centerline Minor Roadway

Vertical Alignment: Y9
Vertical Description:
Vertical Style: Alignment\NCDOT\Prop\ALG_Centerline Minor Roadway

	Station	Elevation
Element: Symmetrical Parabola		
VPC	1000.0000000	377.8214617
VPI	1200.0000000	379.7214617
VPT	1400.0000000	389.4780656
Length:	400.0000000	
Entrance Grade:	0.009	
Exit Grade:	0.049	
r = (g2 - g1) / L:	0.9820755	
K = l / (g2 - g1):	101.8251658	
Middle Ordinate:	1.9641510	

K. The last step before closing the dgn file is to set the roadway profile Active.

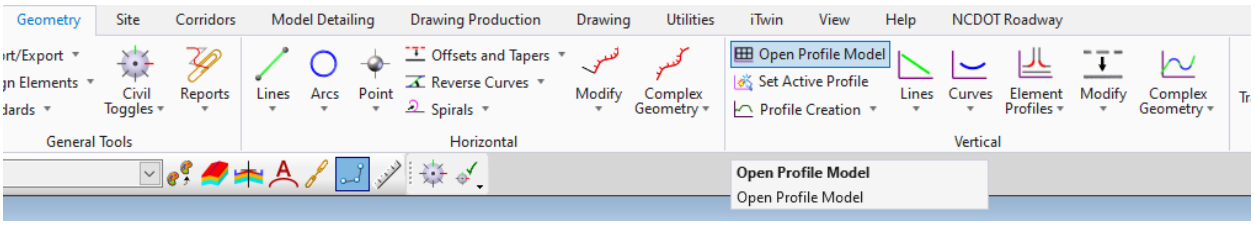


Vertical Geometry Exercise – Table Editor

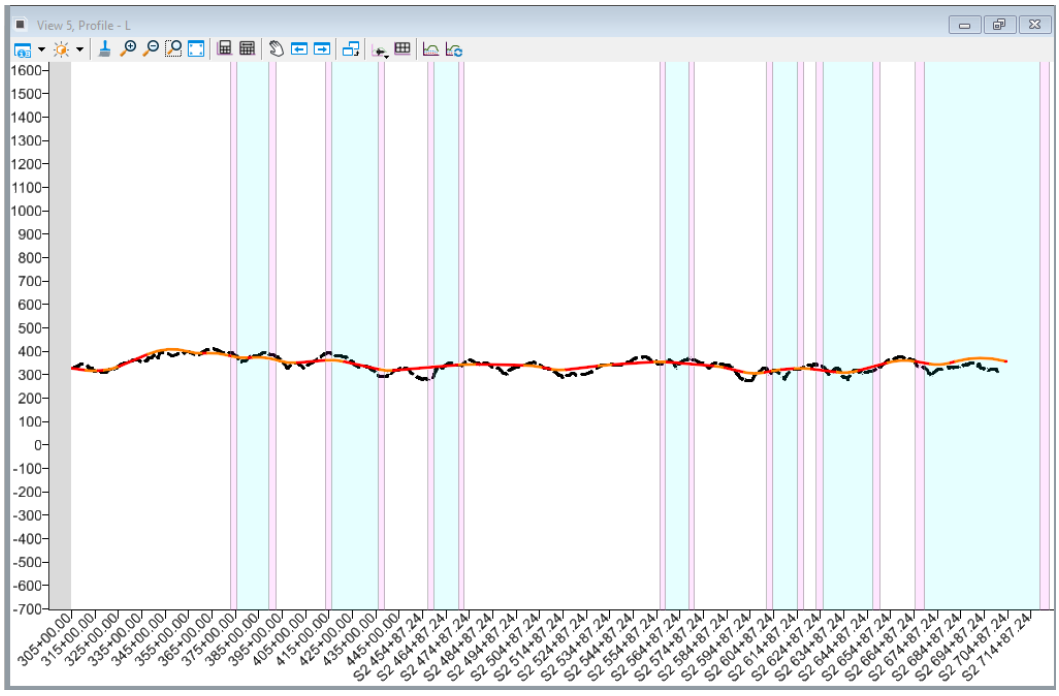
In this exercise, you will learn how to use the table editor to refine and revise a completed vertical profile. The table editor is a tool that will allow the user to edit any aspect of a vertical or horizontal alignment. In this exercise we will focus on the vertical alignment.

Vertical elements can be edited using the text manipulators and drag handles, but in the current version of ORD after the profile is created through the complex geometry commands the ability to edit the VPI stations and elevation through the text manipulators in the Profile Model View is lost. Therefore, the easiest way to complete the editing of a completed vertical profile will be through the Table Editor. This will be especially useful to change VPI station or elevations by small mounts or to make small changes to tangent grades to meet the minimum or maximum requirements. For large scale changes the user may find it easier to make revisions graphically using the grab handles or other methods.

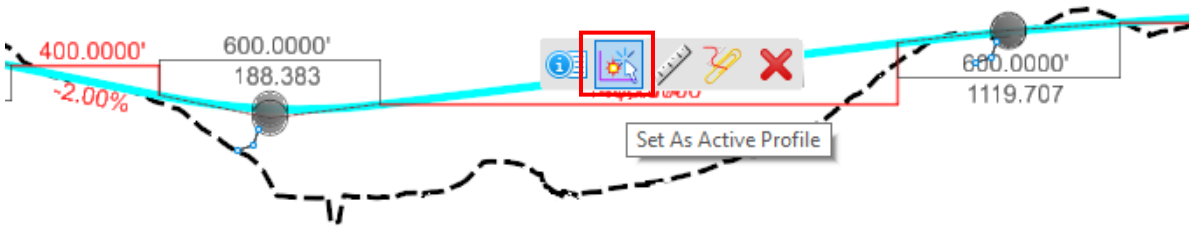
1. **Open the Profile Model View**
   A. Open the ***R-2635C_RDY_ALG_L.dg*** design file.
   B. Open the Profile Model View



   C. The profile Mode View should display with the existing ground line and the proposed grade shown.

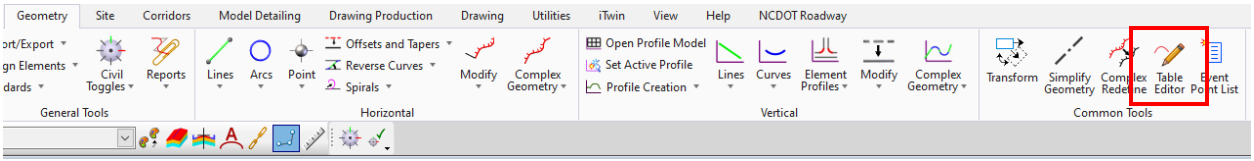


D. Set the proposed profile as the Active Profile. This is not a requirement for using the Table Editor, but it is good practice when working with Vertical Alignments to make sure the user is aware of which alignment is active.

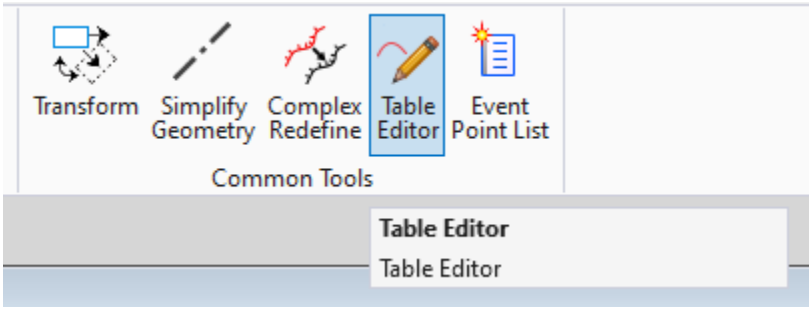


2. Open the Table Editor

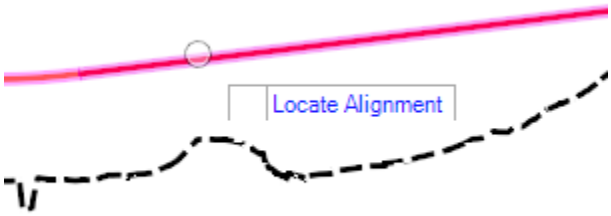
A. The **Table Editor** is located in the *Common Tools* section of the *Geometry* ribbon.



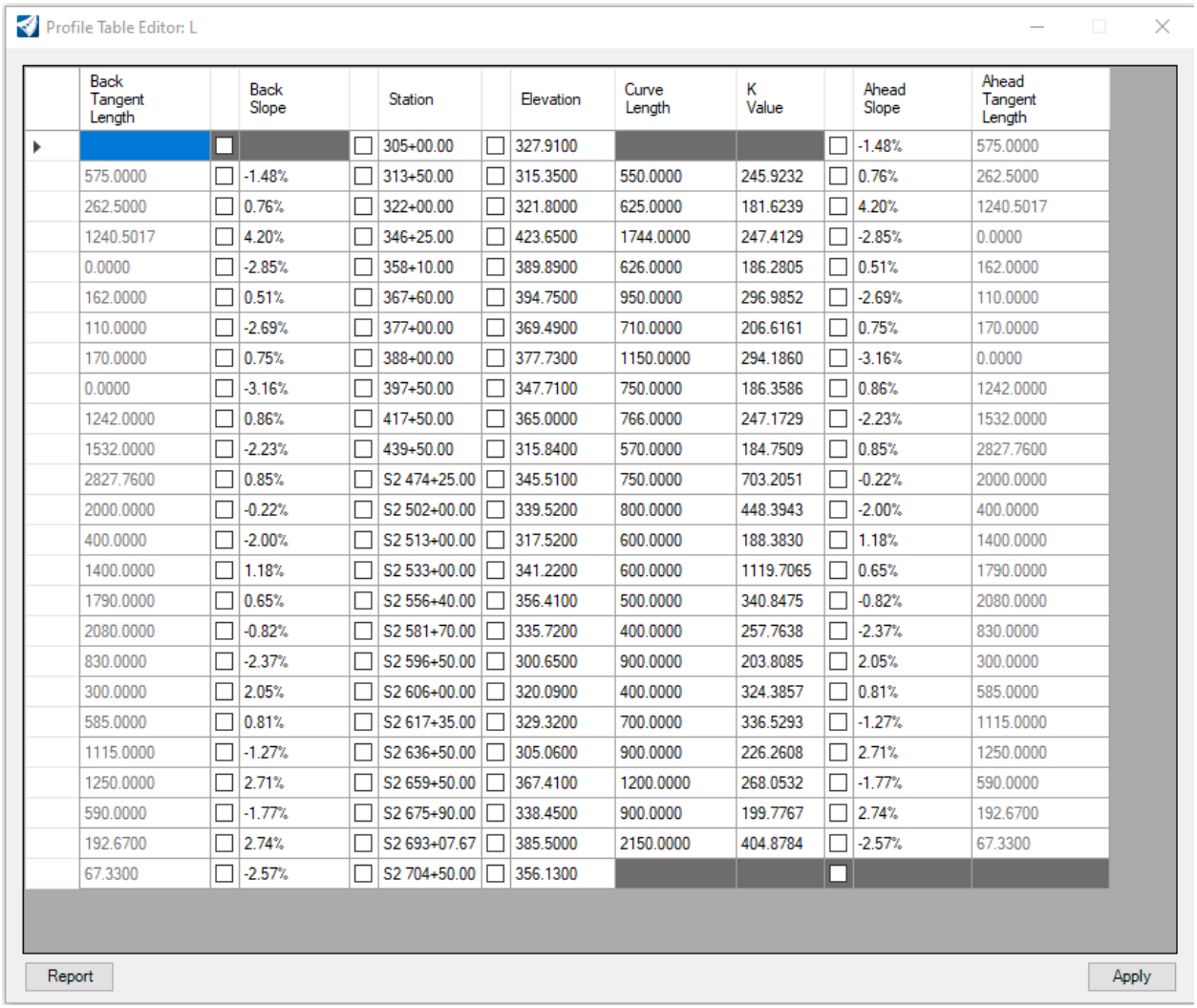
B. Start the Table Editor tool.



C. At the prompt select the alignment that needs to be revised. Note that this tool can be used for either horizontal or vertical alignments. The vertical alignment does not have to be the active profile it could be any profile if there were multiple for a single horizontal alignment.



D. This will activate the Table Editor Dialog



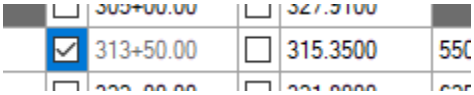
Back Tangent Length	Back Slope	Station	Elevation	Curve Length	K Value	Ahead Slope	Ahead Tangent Length
		305+00.00	327.9100			-1.48%	575.0000
575.0000	-1.48%	313+50.00	315.3500	550.0000	245.9232	0.76%	262.5000
262.5000	0.76%	322+00.00	321.8000	625.0000	181.6239	4.20%	1240.5017
1240.5017	4.20%	346+25.00	423.6500	1744.0000	247.4129	-2.85%	0.0000
0.0000	-2.85%	358+10.00	389.8900	626.0000	186.2805	0.51%	162.0000
162.0000	0.51%	367+60.00	394.7500	950.0000	296.9852	-2.69%	110.0000
110.0000	-2.69%	377+00.00	369.4900	710.0000	206.6161	0.75%	170.0000
170.0000	0.75%	388+00.00	377.7300	1150.0000	294.1860	-3.16%	0.0000
0.0000	-3.16%	397+50.00	347.7100	750.0000	186.3586	0.86%	1242.0000
1242.0000	0.86%	417+50.00	365.0000	766.0000	247.1729	-2.23%	1532.0000
1532.0000	-2.23%	439+50.00	315.8400	570.0000	184.7509	0.85%	2827.7600
2827.7600	0.85%	S2 474+25.00	345.5100	750.0000	703.2051	-0.22%	2000.0000
2000.0000	-0.22%	S2 502+00.00	339.5200	800.0000	448.3943	-2.00%	400.0000
400.0000	-2.00%	S2 513+00.00	317.5200	600.0000	188.3830	1.18%	1400.0000
1400.0000	1.18%	S2 533+00.00	341.2200	600.0000	1119.7065	0.65%	1790.0000
1790.0000	0.65%	S2 556+40.00	356.4100	500.0000	340.8475	-0.82%	2080.0000
2080.0000	-0.82%	S2 581+70.00	335.7200	400.0000	257.7638	-2.37%	830.0000
830.0000	-2.37%	S2 596+50.00	300.6500	900.0000	203.8085	2.05%	300.0000
300.0000	2.05%	S2 606+00.00	320.0900	400.0000	324.3857	0.81%	585.0000
585.0000	0.81%	S2 617+35.00	329.3200	700.0000	336.5293	-1.27%	1115.0000
1115.0000	-1.27%	S2 636+50.00	305.0600	900.0000	226.2608	2.71%	1250.0000
1250.0000	2.71%	S2 659+50.00	367.4100	1200.0000	268.0532	-1.77%	590.0000
590.0000	-1.77%	S2 675+90.00	338.4500	900.0000	199.7767	2.74%	192.6700
192.6700	2.74%	S2 693+07.67	385.5000	2150.0000	404.8784	-2.57%	67.3300
67.3300	-2.57%	S2 704+50.00	356.1300				

E. The dialog will allow the user to edit the Back Slope, VPI Station, VPI Elevation, Curve Length, K Value or Ahead Slope.

Back Tangent Length	Back Slope	Station	Elevation	Curve Length	K Value	Ahead Slope	Ahead Tangent Length
		305+00.00	327.9100			-1.48%	575.0000
575.0000	-1.48%	313+50.00	315.3500	550.0000	245.9232	0.76%	262.5000
262.5000	0.76%	322+00.00	321.8000	625.0000	181.6239	4.20%	1240.5017

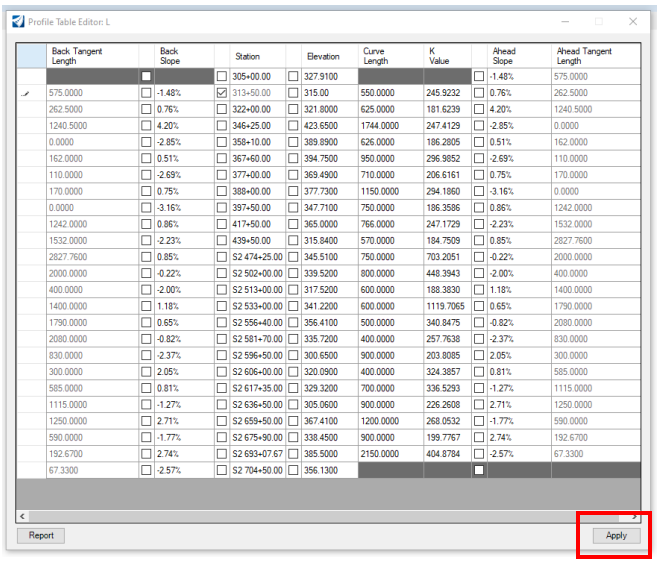
F. By Checking the box next to one of the values the user is locking that value. In this example if the VPI Elevation is changed, the VPI will remain at station 313+50.00 and the Back Slope and Front Slope will adjust.

G. Find the row with the VPI at Station 313+50 and check the box next to the station.

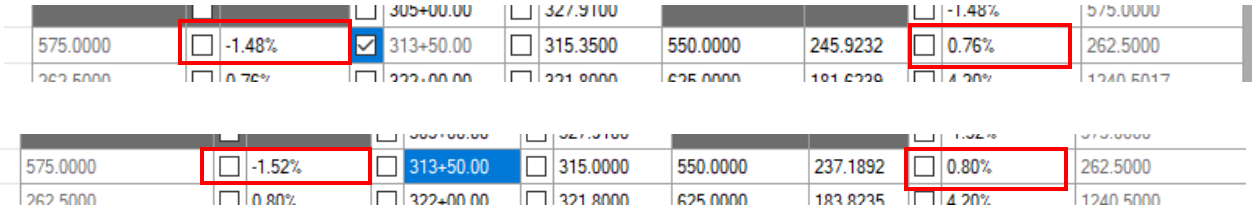


H. Change the elevation to 315.00'.

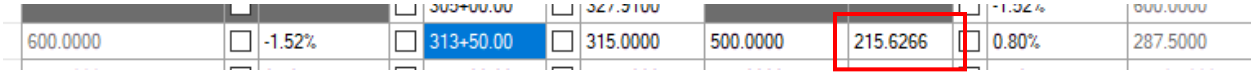
I. Select Apply and the profile will be updated with the new VPI elevation.



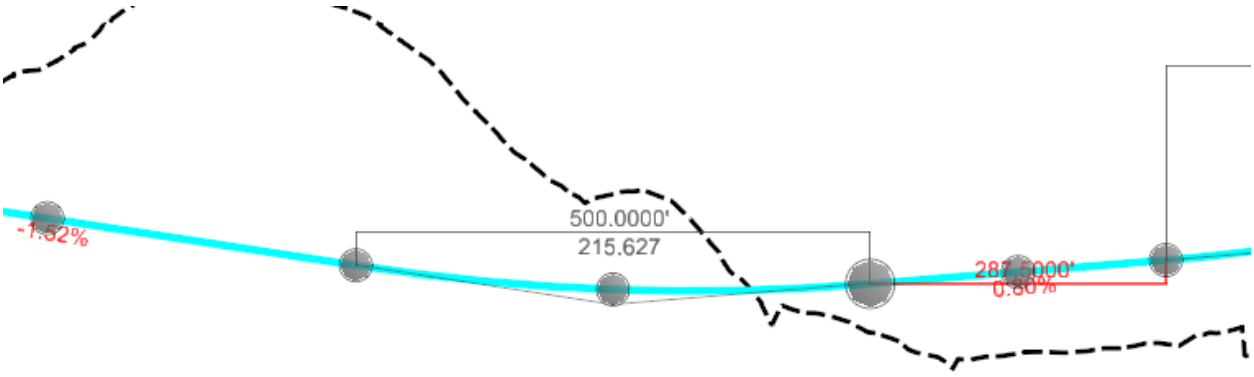
J. Note that the VPI Station has remained unchanged at 313+50.00, the elevation change has been applied and the Back Slope and Ahead Slope have been updated to match.



K. At the same VPI change the vertical curve length from 550’ to 500’ and select apply to complete the change. Note that the K value changed to reflect the new curve length.



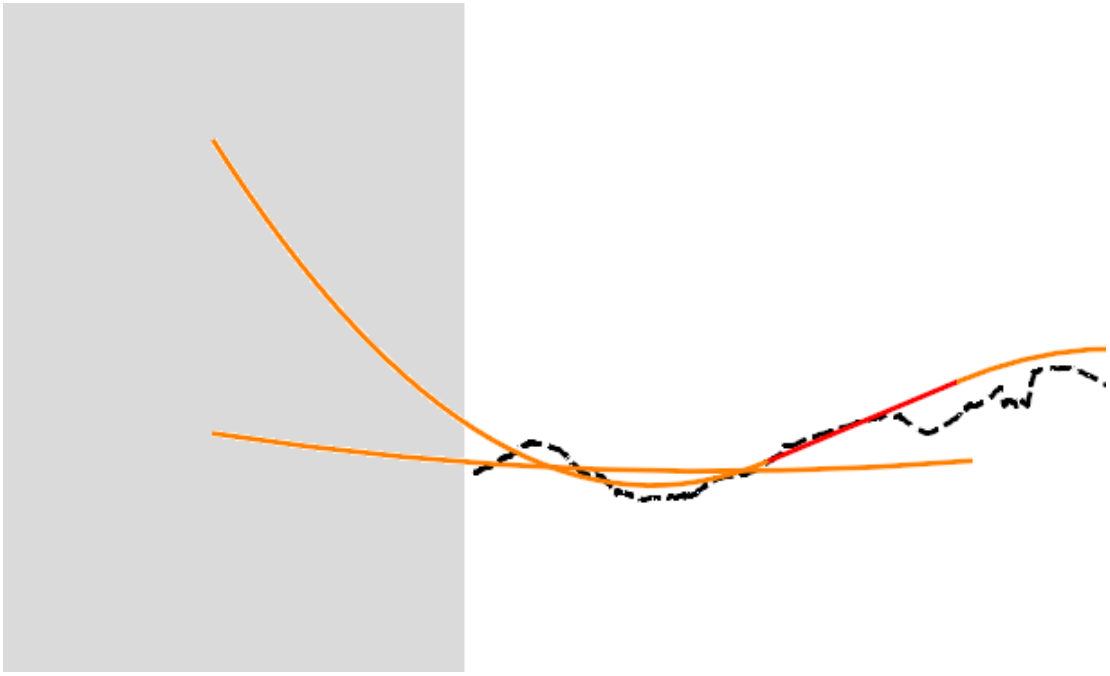
L. This change is also automatically updated in the Profile Model View.



M. Change the same vertical curve from 500’ to 5000’. This will produce an error because the curve is too long and conflicts with the Begin Profile station and the ahead vertical curve. Note the Table Editor displays in red the values that conflict.

Back Tangent Length	Back Slope	Station	Elevation	Curve Length	K Value	Ahead Slope	Ahead Tangent Length
		288+50.00	352.9706			-1.52%	0.0000
0.0000	-1.52%	313+50.00	315.0000	5000.0000	2156.2659	0.80%	1240.5000
0.0000	0.80%	322+00.00	321.8000	625.0000	183.8235	4.20%	1240.5000
1240.5000	4.20%	346+25.00	423.6500	1744.0000	247.4129	-2.85%	0.0000

N. This error is also displayed in the Profile Model view.



O. If this kind of error occurs the profile is still treated as a complex element and the conflicting values in the profile editor can be revised. Change the vertical curve length back to 550’

P. Find the line with the VPI at Station 417+50. Check the box next to the 0.86% Back Slope.

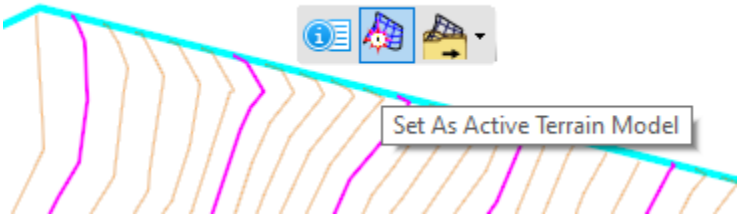
Change the VPI Station to 418+00 and press Apply. Note that the Back Slope remained the same but the VPI Elevation and Front Slope Changed.

Q. The table editor is a simple and powerful tool for revising vertical alignments. Part of the Best Practice for using the table editor is to make a single revision at a time. While it is possible to revise multiple curves and VPIs and Apply them all at once significantly less issues will arise by entering and completing a single revision at a time.

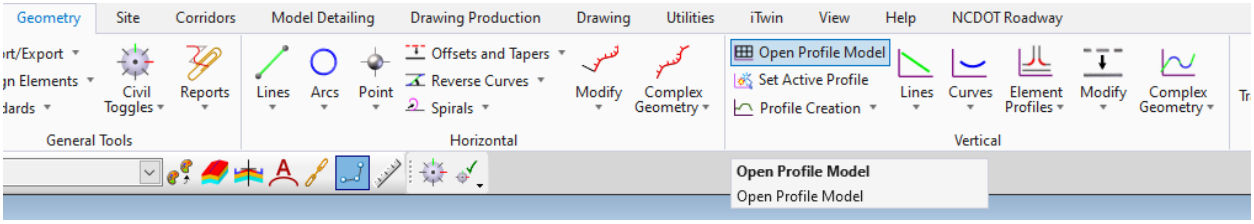
Vertical Geometry Exercise – Best Fit

In this exercise, you will learn how to quickly and easily create and a Best Fit Profile. The Best Fit Profile is created based on upper and lower limits and a reference profile. The most common use for this tool will likely be generating overlay profiles based on the existing ground at the centerline. But the reference profile can be any profile, existing or proposed, and the upper and lower limits can be based on any design parameters that apply.

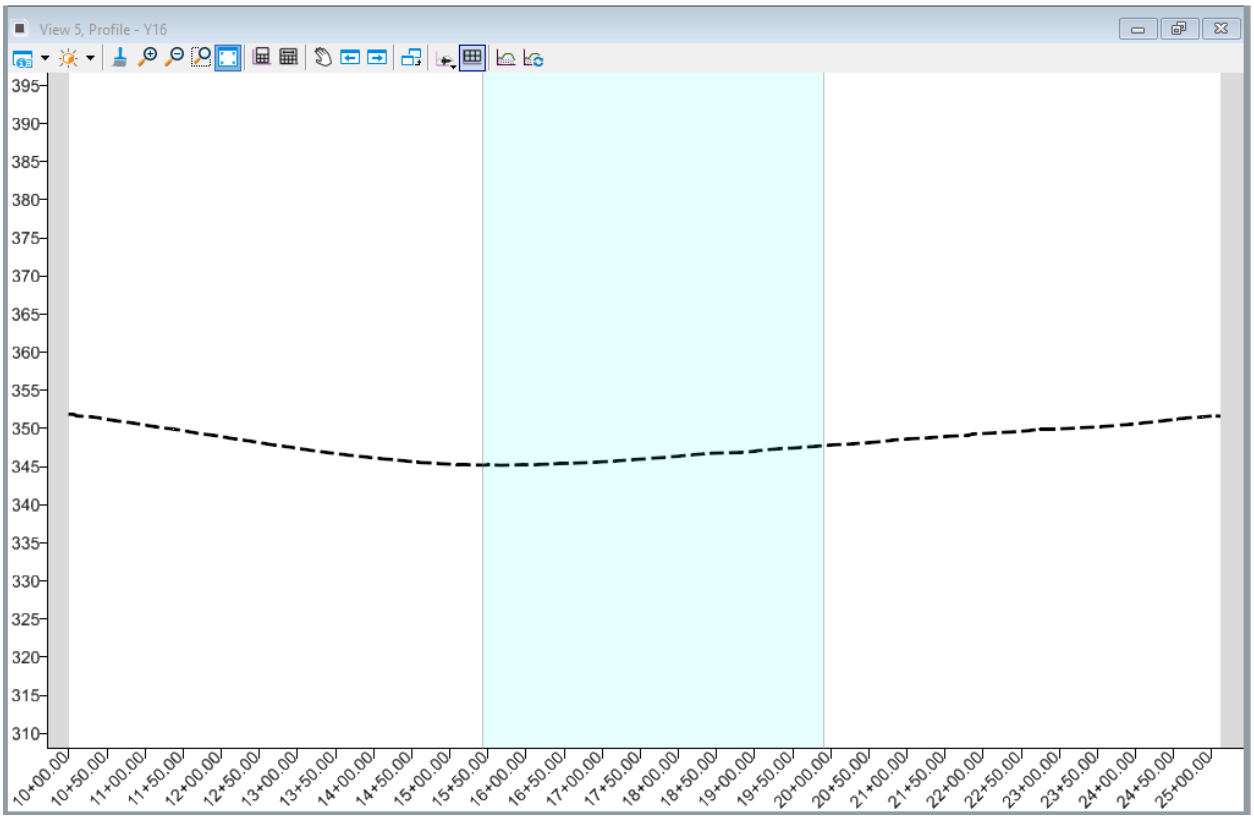
1. **Open the Profile Model View**
   A. Open the ***R-2635C_RDY_ALG_Y16.dg*** design file.
   B. Set the Existing Terrain Model as the Active Terrain Model



   C. Open the Profile Model View

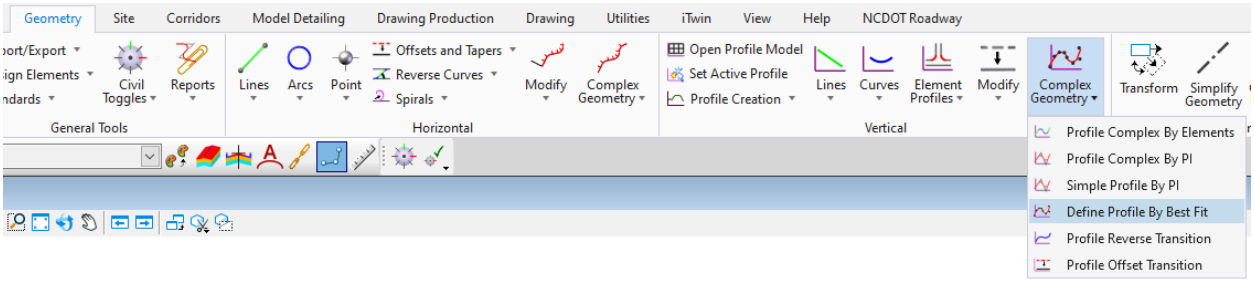


D. The profile Mode View should display with the existing ground line shown.

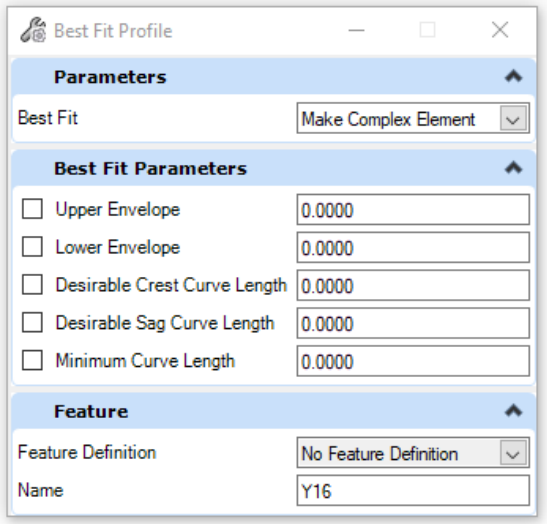


2. Define Profile by Best Fit

A. Start the **Define Profile By Best Fit** tool from the Complex Geometry tool group in the *Vertical* section of the *Geometry* ribbon.



B. The dialog will appear that will allow user defined constraints that the program will use to calculate a best fit solution.



- Parameters – Best Fit
  1. Make Complex Element will create a single complex element, a finished vertical profile, this would be used if the entire profile needs to be designed as a best fit solution
  2. Make Single Element will create individual elements, this would be used if only a portion of the profile needed to be designed as a best fit solution
- Upper Envelope
  1. This is the maximum height over the reference profile
- Lower Limit
  1. This is the minimum height over the reference profile.
- Desirable Crest Curve Length
  1. This is the desired length of the crest curve, the curves created can be more or less than this number
- Desirable Sag Curve Length
- Minimum Curve Length
  1. This is the minimum length of a crest or sag vertical curve, all curves will eb at least this long.

3. Best Fit Example 1

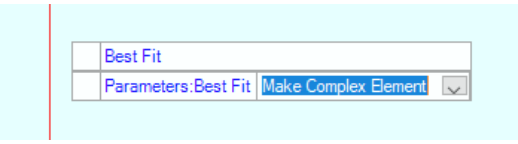
A. For this example, we will be designing an overlay profile based on the existing ground at the centerline. To illustrate the effect that the dialog constraints can have on the profile we will create several profiles using different values.

B. Set the Feature Definition to ALG_Centerline Minor Roadway

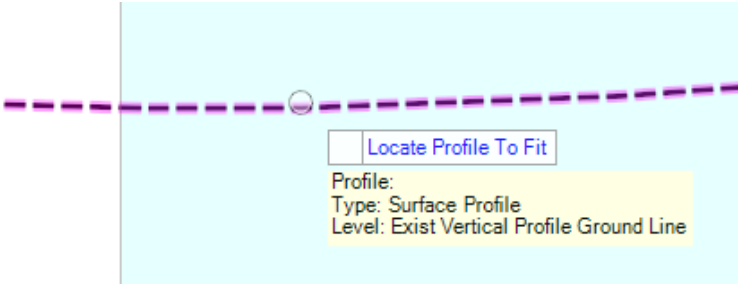
C. Set the Dialog as follows:

- Best Fit = Make Complex Element
- Upper Envelope = 2.0’
- Lower Envelope = 0.125’
- Minimum Curve Length = 200’
- Name = Y16

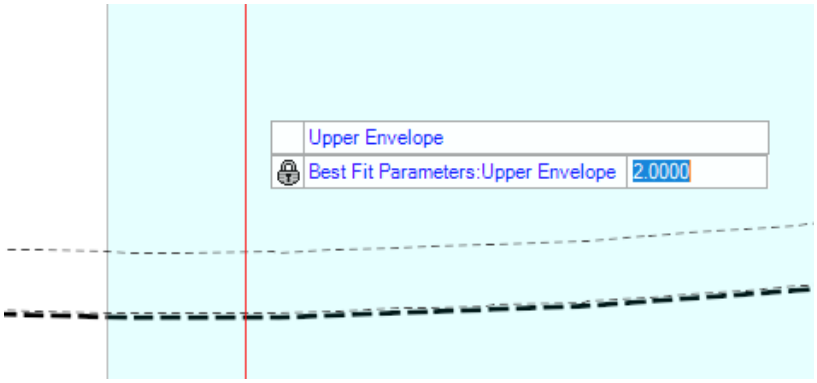
D. Left click to accept the Make Complex Element option



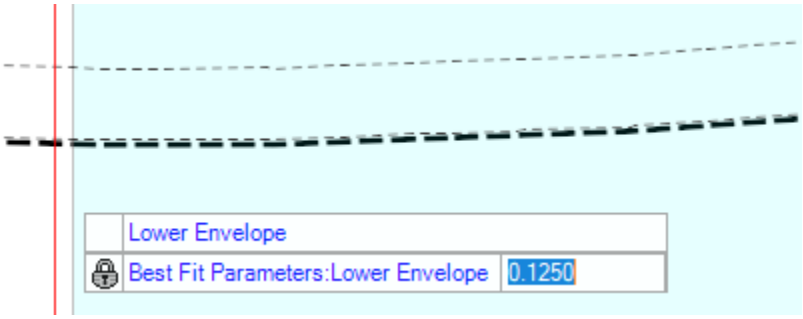
E. Left click on the existing ground line to locate the reference profile.



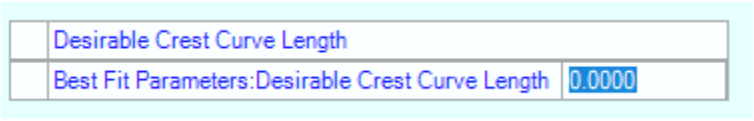
F. Left click to accept the 2.0’ Upper Envelope, note the thin dashed black line that appears to indicate the location of the envelope.



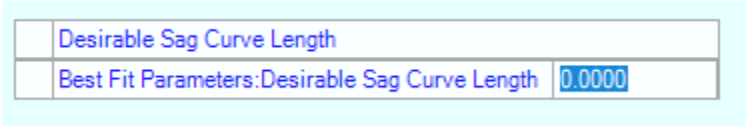
G. Left click to accept the Lower Envelope limit of 0.125’.



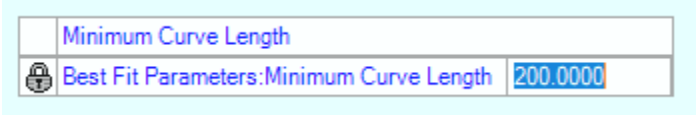
H. Left click to Accept Desirable Crest Curve Length



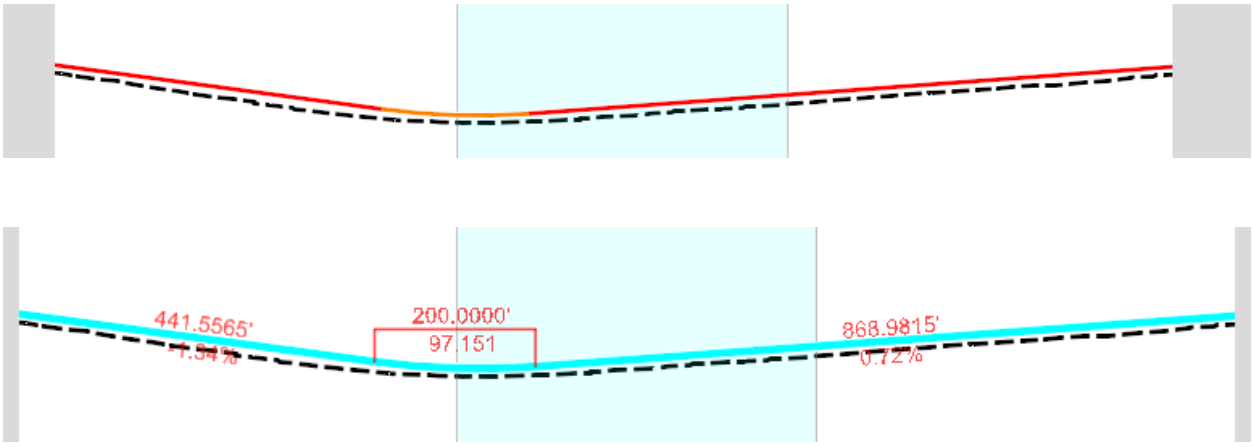
I. Left Click to Accept Desirable Sag Curve Length



J. Left Click to Accept the Minimum Curve Length



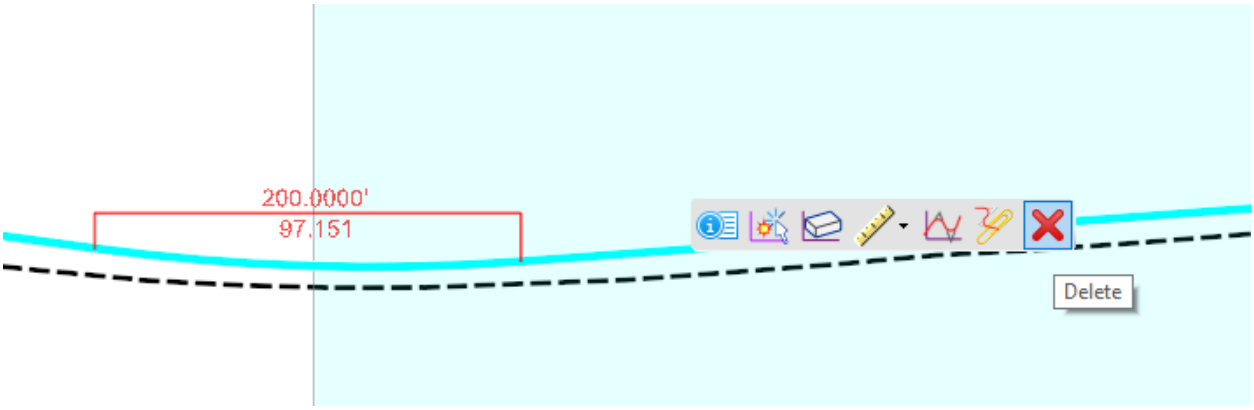
K. The tool generated a very simple vertical profile with one vertical curve with a 200.00’ length. This is because a wide design envelope was specified.



4. Best Fit Example 2

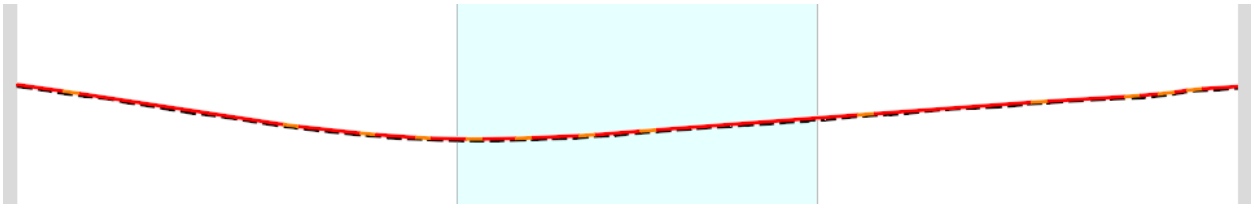
A. For this example, we will define a much smaller envelope and a smaller minimum vertical curve length.

B. Delete the recently created vertical profile by selecting delete from the pop-up menu activated when the profile is selected.

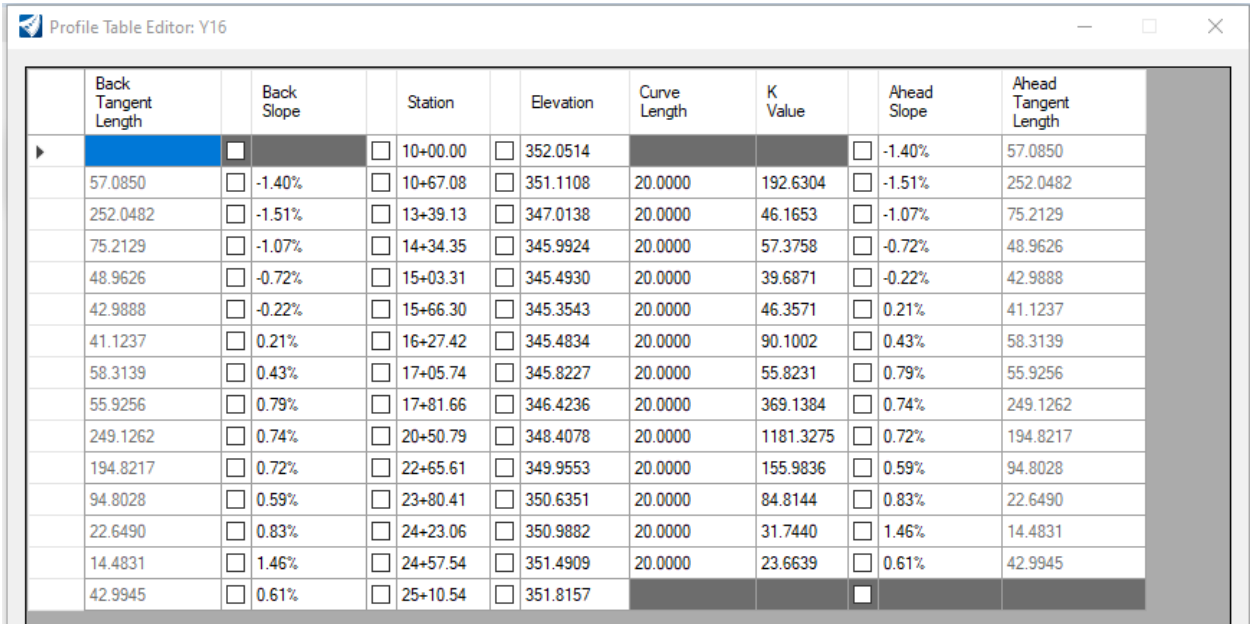


C. Reset the design parameters in the dialog
- Set the Upper Envelope to 0.25’
- Set the Lower Envelope to 0.125’
- Set the Minimum Curve Length to 20’

D. Left click to start the tool and then follow the heads up prompts in the same way as Example 1 and create the Best Fit profile.



E. By starting the Table Editor, you can see that with these constraints the profile created has many short tangents and small vertical curves. These were required to fit the profile within the relatively small design window of 0.125’ to 0.250’



Back Tangent Length	Back Slope	Station	Elevation	Curve Length	K Value	Ahead Slope	Ahead Tangent Length
		10+00.00	352.0514			-1.40%	57.0850
57.0850	-1.40%	10+67.08	351.1108	20.0000	192.6304	-1.51%	252.0482
252.0482	-1.51%	13+39.13	347.0138	20.0000	46.1653	-1.07%	75.2129
75.2129	-1.07%	14+34.35	345.9924	20.0000	57.3758	-0.72%	48.9626
48.9626	-0.72%	15+03.31	345.4930	20.0000	39.6871	-0.22%	42.9888
42.9888	-0.22%	15+66.30	345.3543	20.0000	46.3571	0.21%	41.1237
41.1237	0.21%	16+27.42	345.4834	20.0000	90.1002	0.43%	58.3139
58.3139	0.43%	17+05.74	345.8227	20.0000	55.8231	0.79%	55.9256
55.9256	0.79%	17+81.66	346.4236	20.0000	369.1384	0.74%	249.1262
249.1262	0.74%	20+50.79	348.4078	20.0000	1181.3275	0.72%	194.8217
194.8217	0.72%	22+65.61	349.9553	20.0000	155.9836	0.59%	94.8028
94.8028	0.59%	23+80.41	350.6351	20.0000	84.8144	0.83%	22.6490
22.6490	0.83%	24+23.06	350.9882	20.0000	31.7440	1.46%	14.4831
14.4831	1.46%	24+57.54	351.4909	20.0000	23.6639	0.61%	42.9945
42.9945	0.61%	25+10.54	351.8157				

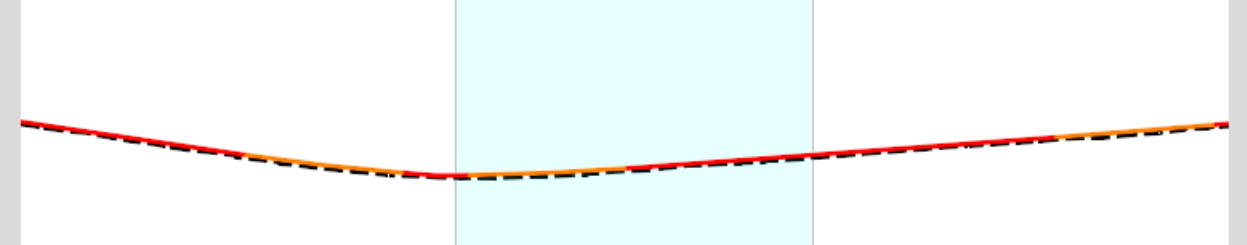
5. Best Fit Example 3

A. For this example, we will use more appropriate design parameters to produce a profile that will be closer to the desired result. There will always be some refinement that will be required but the initial result should be very close.

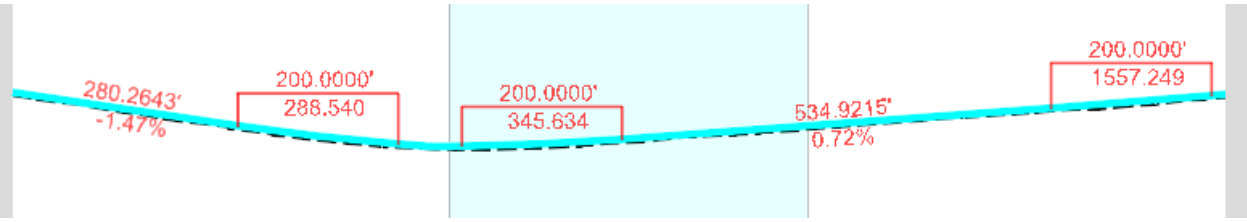
B. Delete the recently created vertical profile by selecting delete from the pop-up menu activated when the profile is selected.

C. Reset the design parameters in the dialog
- Set the Upper Envelope to 0.25’
- Set the Lower Envelope to 0.125’
- Set the Minimum Curve Length to 20’
- Set the name to Y16

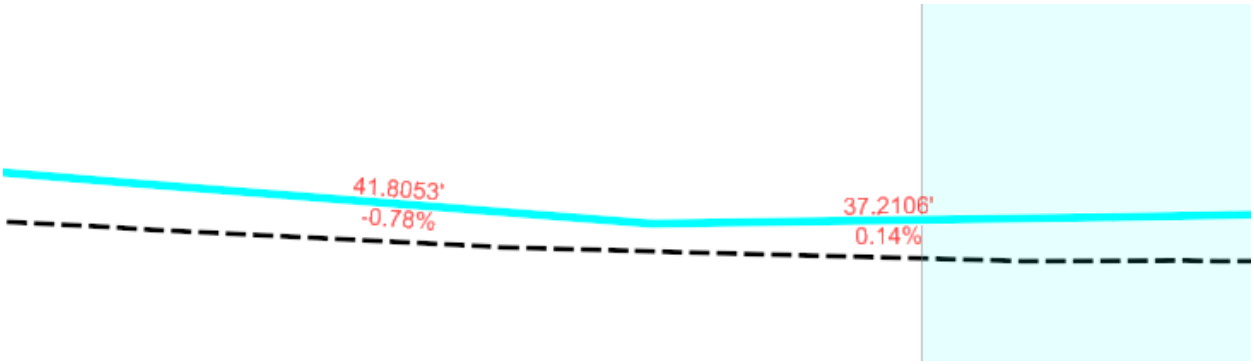
D. Left click to start the tool and then follow the heads up prompts in the same way as Example 1 and create the Best Fit profile.



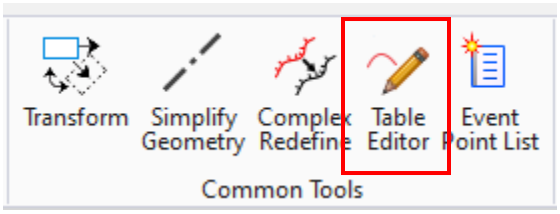
E. This profile contains 3 vertical curves.



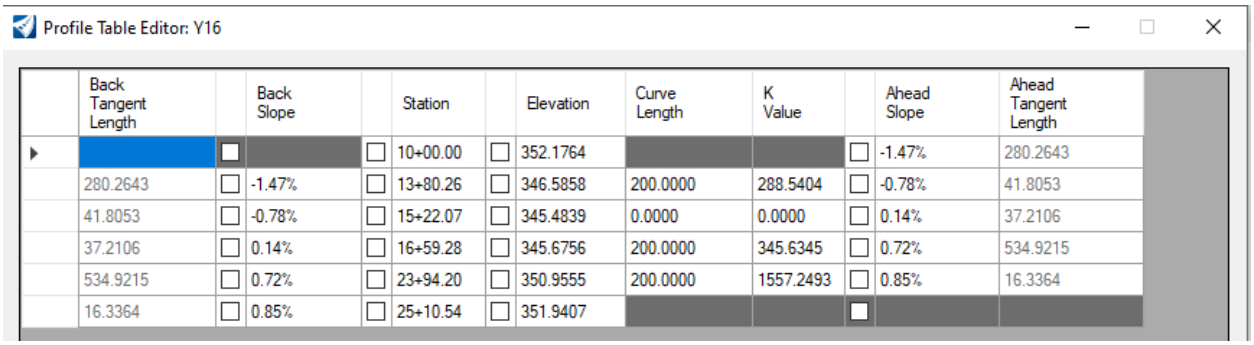
F. This profile also contains an error, in between the first and second vertical curve there is a VPI with no curve. This was caused because the profile cannot violate the Upper or Lower Limit or the Minimum Curve length. In this area there is no curve that will satisfy those requirements so a profile VPI with no curve was created.



G. One solution would be to modify the minimum curve length or the Upper limit until an acceptable solution was created. In this case we will use the **Table Editor** to revise the profile.



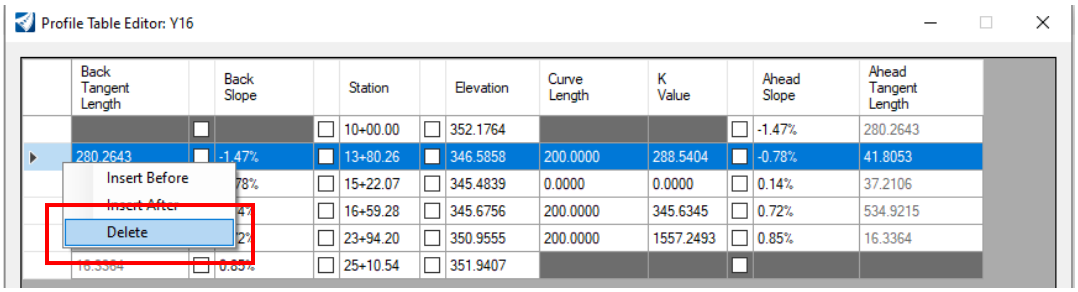
H. Start the Table Editor dialog.



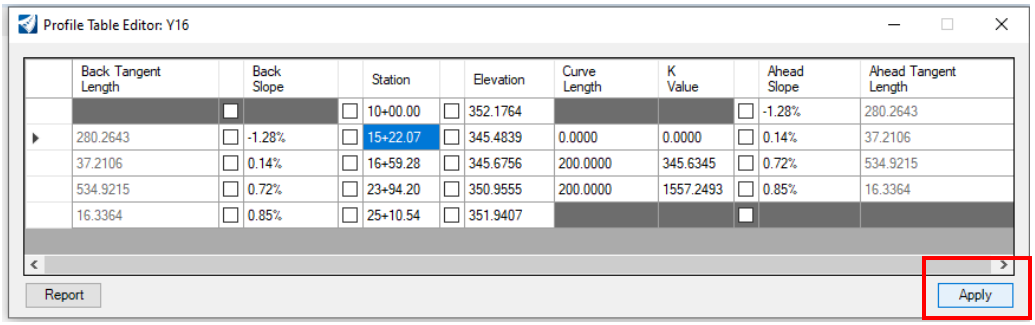
Back Tangent Length	Back Slope	Station	Elevation	Curve Length	K Value	Ahead Slope	Ahead Tangent Length
		10+00.00	352.1764			-1.47%	280.2643
280.2643	-1.47%	13+80.26	346.5858	200.0000	288.5404	-0.78%	41.8053
41.8053	-0.78%	15+22.07	345.4839	0.0000	0.0000	0.14%	37.2106
37.2106	0.14%	16+59.28	345.6756	200.0000	345.6345	0.72%	534.9215
534.9215	0.72%	23+94.20	350.9555	200.0000	1557.2493	0.85%	16.3364
16.3364	0.85%	25+10.54	351.9407				

I. To Revise the Profile
- Remove the VPI at Station 13+80.26
- Remove the VPI at Station 16+59.28
- Add a Vertical Curve to the VPI at Station 15+22.07

J. Left click on the left most column in the box on the same line as the VPI at station 13+80.26 to highlight the row. Then right click to activate a pop up menu. Select Delete and left click.

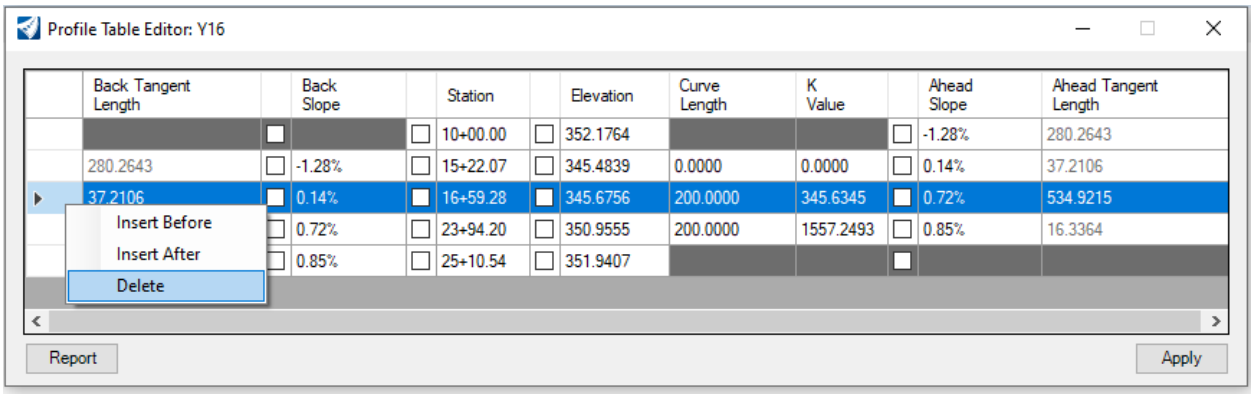


K. Left click apply to finish deleting the VPI.

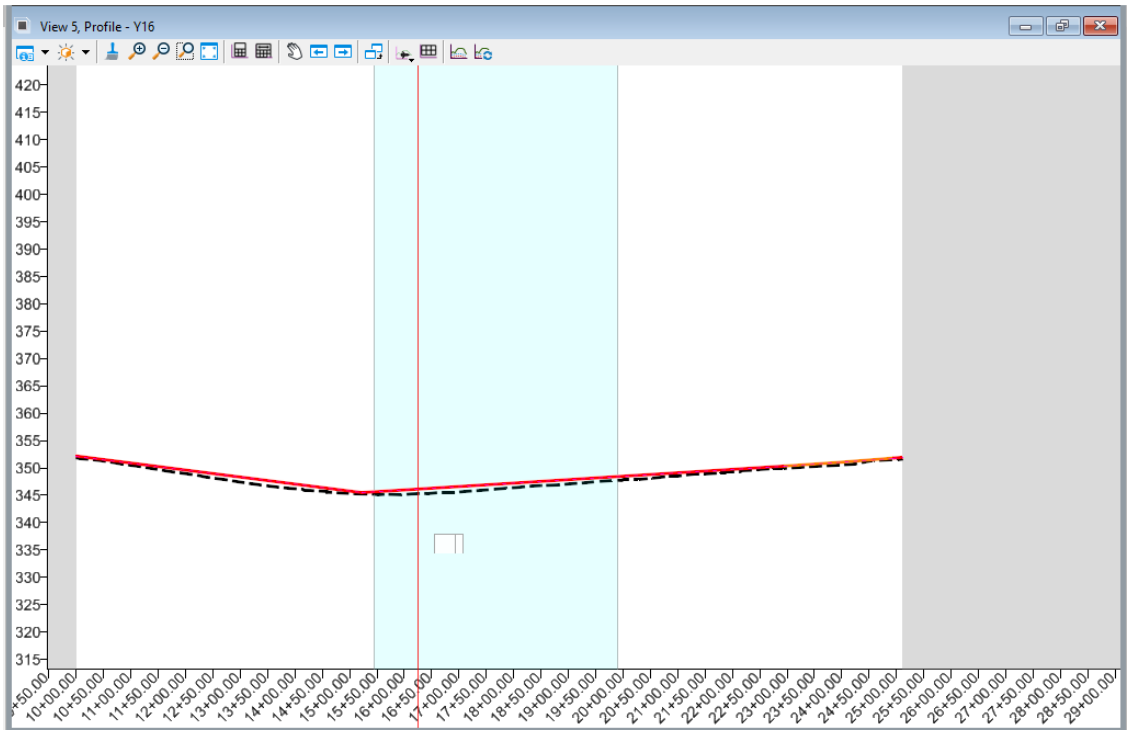


Back Tangent Length	Back Slope	Station	Elevation	Curve Length	K Value	Ahead Slope	Ahead Tangent Length
		10+00.00	352.1764			-1.28%	280.2643
280.2643	-1.28%	15+22.07	345.4839	0.0000	0.0000	0.14%	37.2106
37.2106	0.14%	16+59.28	345.6756	200.0000	345.6345	0.72%	534.9215
534.9215	0.72%	23+94.20	350.9555	200.0000	1557.2493	0.85%	16.3364
16.3364	0.85%	25+10.54	351.9407				

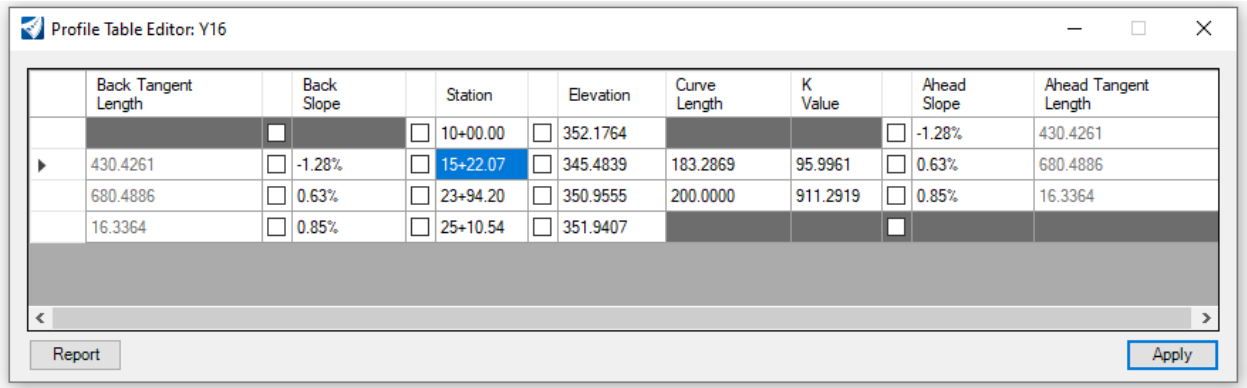
L. Repeat the process for the VPI at Station 16+59.28.



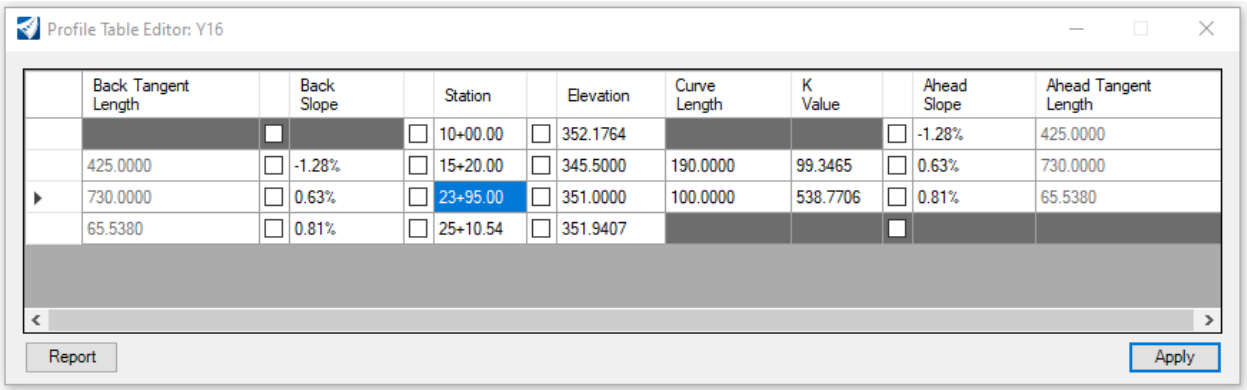
M. The profile should no look like this a VPI with no curve at Station 15+22.07, and a 200’ Vertical curve at Station 23+94.20.



N. This road has a design speed of 50 mph, which is a minimum K Value for a Sag Curve of 96. Enter 96 into the K value section of the VPI at Station 15+22.07 and Press Apply. This will create a vertical curve with a length of 183.29'.



O. The final revision will eb to refine the stations, elevations and curve lengths.
P. Change the First VPI to:
   - Station = 15+20.00
   - Elevation = 345.50
   - Curve Length = 190'
Q. Change the Second VPI to
   - Station 23+95.00
   - Elevation to 351.00
   - Curve length to 100.00'



R. This completes the Best Fit Profile. This profile can be used for the initial corridor model. Further refinement can be achieved with tool available in the Modeling section that allow for profile adjustments based on Cross Slope corrections.