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Workshop – X13

Advanced Geometrical Layout for Compound and Reversed Curves

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Preface

In this workshop, you will construct horizontal alignments utilizing the V8*i* SELECTseries 2 Horizontal Element tools. We have structured the contents of the exercises herein to allow your interaction with a broad range of available tools, however, we will not use every tool. Also, it is impossible to engineer a complete interchange in the time frame of this workshop, but we will use the tools in their real-life context, so you can see how to utilize them in your own engineering projects.

This workshop is applicable for InRoads family of products. In this workshop, we will use Power InRoads V8*i* 08.11.07.566

There are more exercises in this manual than we will have time to cover today. We will all complete the basic set of exercises, and for those veteran users in the group who complete them and still have time left in the exercise session, you are welcome to work on the optional exercises.

In order for all participants to design the same layout and to stay on course and on time, we request that all participants utilize the files as listed in the workshop materials. At the beginning of each chapter, we will start with a fresh set of data. This ensures that everyone is using the same data.

The workshop guide is yours to take with you. If you don't finish all the exercises, or just want to work with the dataset upon return to your office, the datasets (both initial and completed files) are provided on the Conference DVD. Many workshops will also have videos of all exercises on the DVD.

Note Prerequisite Knowledge Level: Participant should have a basic understanding of road design principles and be fluent in use of MicroStation and the native application (InRoads) or of the Power product.

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Chapter 1: Fitting a Curve into an Existing Geometry

CHAPTER OBJECTIVE:

In this scenario, there has been an error in construction which will be corrected by laying out new geometry, holding portions of the alignment constant while changing a defined portion of the alignment. There is a non-collinear tangent element that is causing a discontinuity in the alignment. It is necessary to place another curve in the alignment between the first and last curve. Requirement is to maintain the PC and PT of the entire curve set.

STARTING POWER INROADS

1. Double-click the Power InRoads icon.

Note	The MicroStation Manager appears.

2. An alternate path for launching Power InRoads is **Start > All Programs > Bentley > Bentley Power InRoads (SELECTseries 2) > Bentley Power InRoads (SELECTseries 2)**.

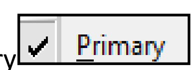
OPEN A CAD FILE

1. Set the directory to C:\2012_BT_Civil\BC2WK2 - Advanced Geometrical Layout\Data\BC2WK2 Advanced Geometrical Layout
2. Open the CAD file horiz_elem.dgn

OPEN FILES IN POWER INROADS

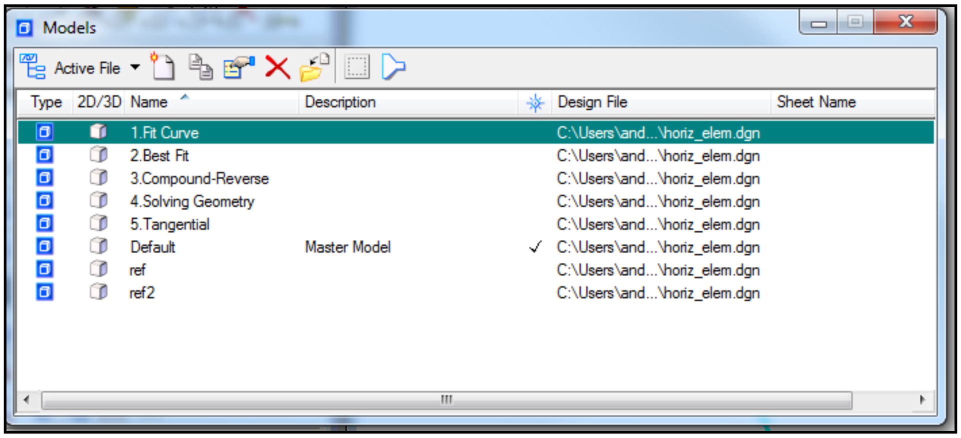
1. Select **File > Power InRoads File > Open**.
2. Go to the following directory: *C:\2012_BT_Civil\BC2WK2 - Advanced Geometrical Layout\Data\BC2WK2 Advanced Geometrical Layout*
3. Open the following files: *alignments.xin* and *HorizElem.alg*

TURN ON THE PRIMARY TOOLBAR

1. Select Tools > Primary 

OPEN MODEL

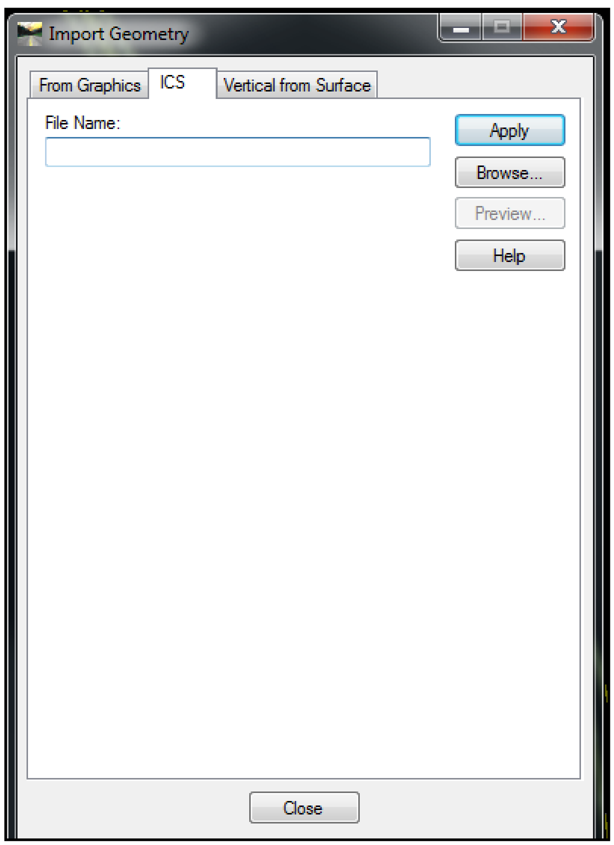
1. Select Models 
2. Verify that Model *1.Fit Curve* is active



3. Close Models 

IMPORT ALIGNMENT

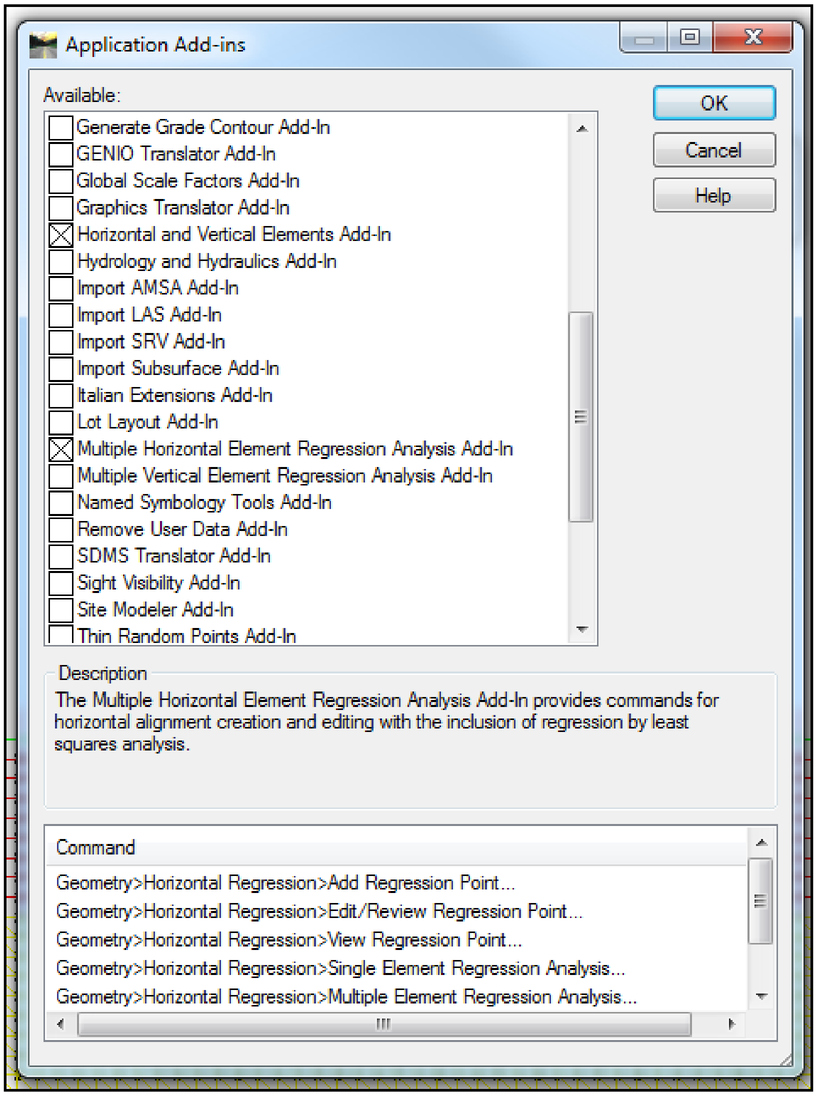
1. Select **File > Power InRoads Import > Geometry > ICS**



2. Browse to the following directory: *C:\2012_BT_Civil\BC2WK2 - Advanced Geometrical Layout \Data\BC2WK2 Advanced Geometrical Layout \Fit Curve*
   a. Select *Survey300.ics* > Open
   b. Apply
   c. Close

Application Add-In

1. Select **Power InRoads Tools > Application Add-ins**
   a. Select *Horizontal And Vertical Elements Add-in* and *Multiple Horizontal Element Regression Analysis Add-in*

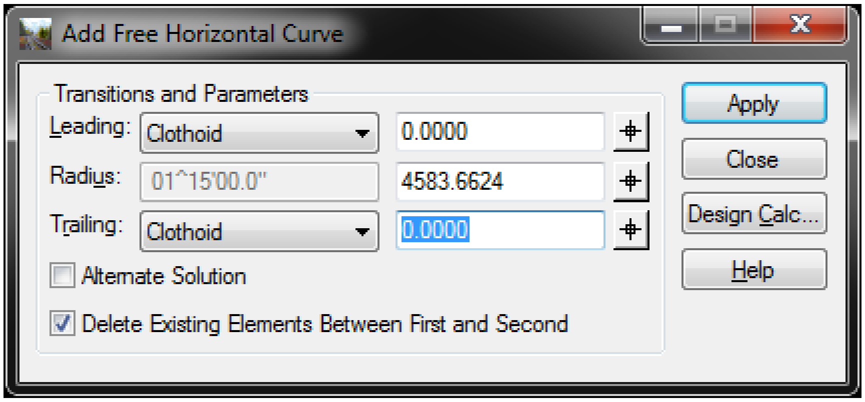


   b. Apply
   c. Close

Edit Alignment

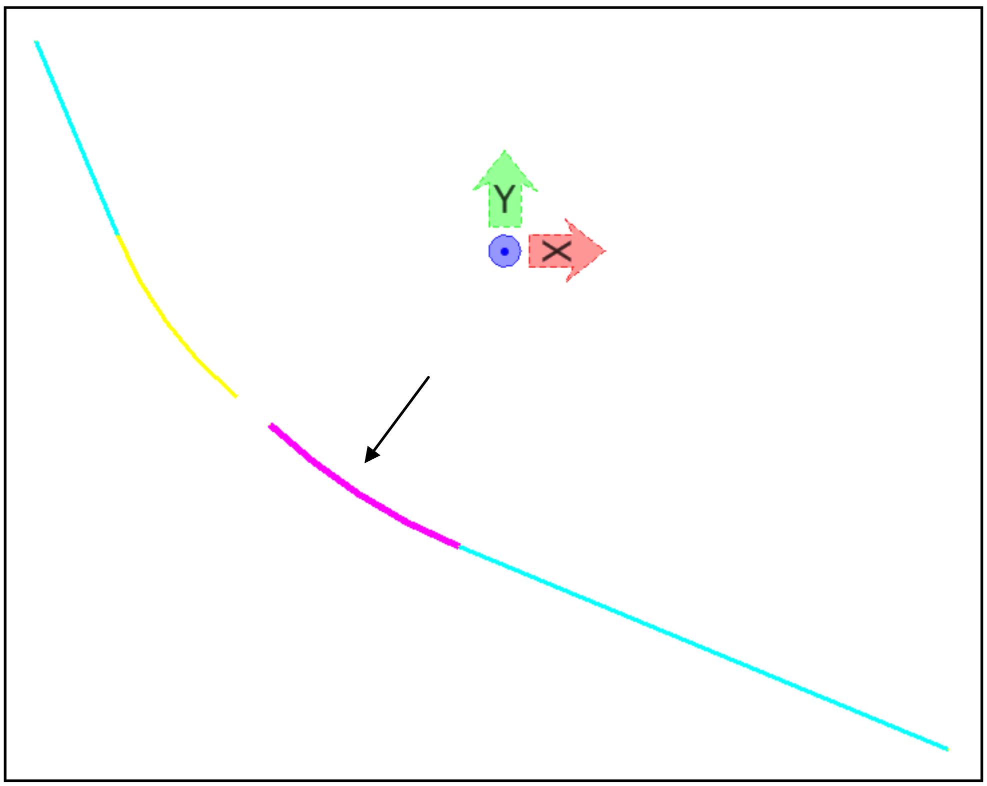
1. Select **Geometry > Horizontal Element > Check Integrity**
   a. Review the alignment and note that the linear element causes non-collinear issues in the alignment
   b. Close
2. Select **Geometry > Horizontal Element > Add Free Curve**
   a. Set the radius to be 1^15’00” (d1.25) > Tab

b. Check on *Delete Existing Elements Between First and Last*



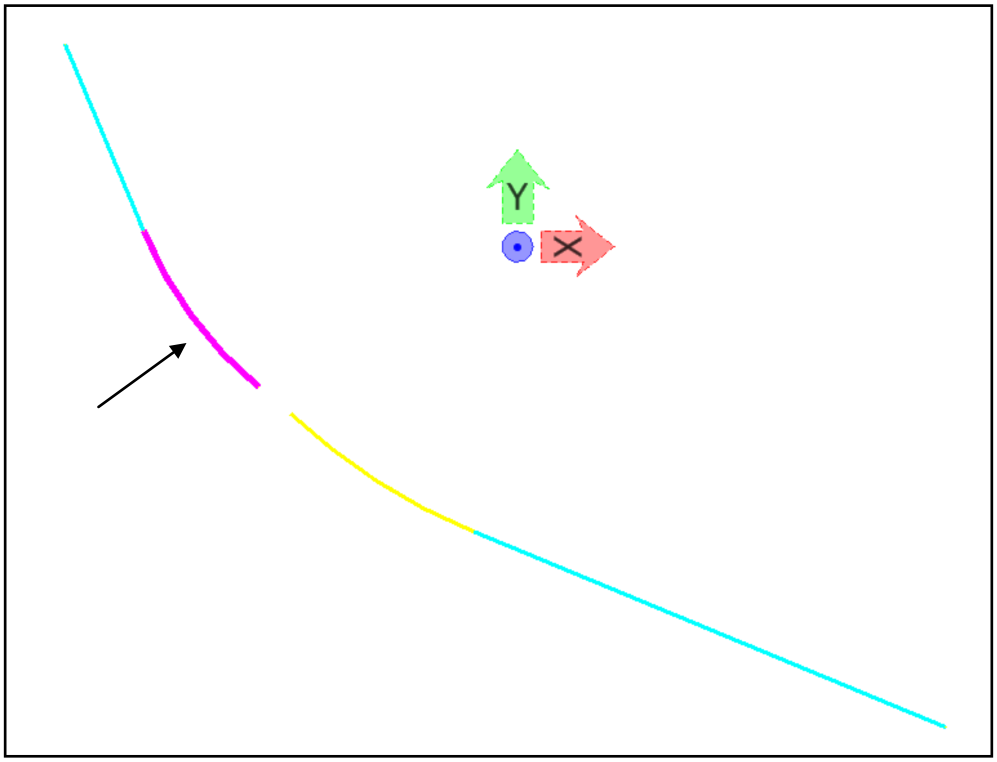
c. Apply

d. Select the first element



First Element

e. Select the second element



Second Element

f. Data point to Accept the solution

g. Reset and Close to exit the Add Free Horizontal Curve command

3. Select **Geometry > View Geometry > Horizontal Annotation**

   a. Load Preference: *Fit Curve*

      i. Select Display: Elements, Radials, and Subtangents

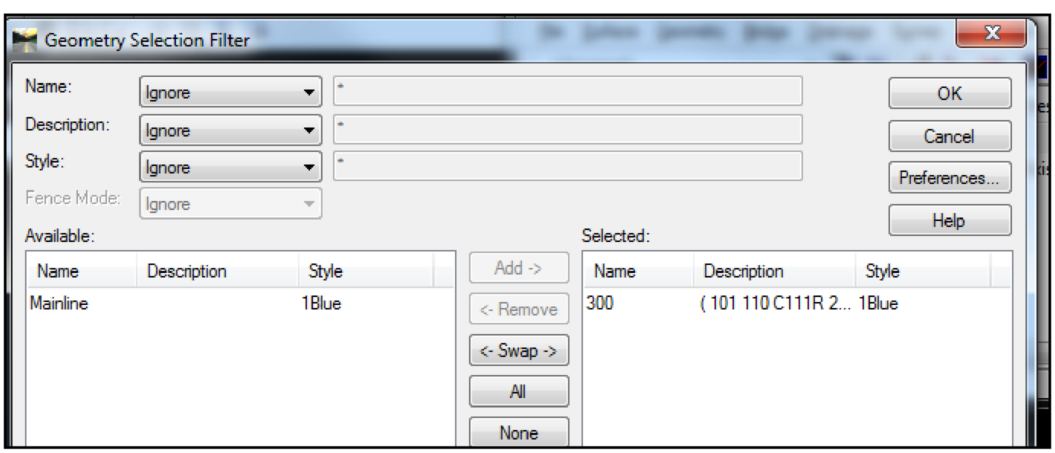
   b. Include the *300* horizontal alignment

      i. Place cursor in the *Include* field for Horizontal Alignments

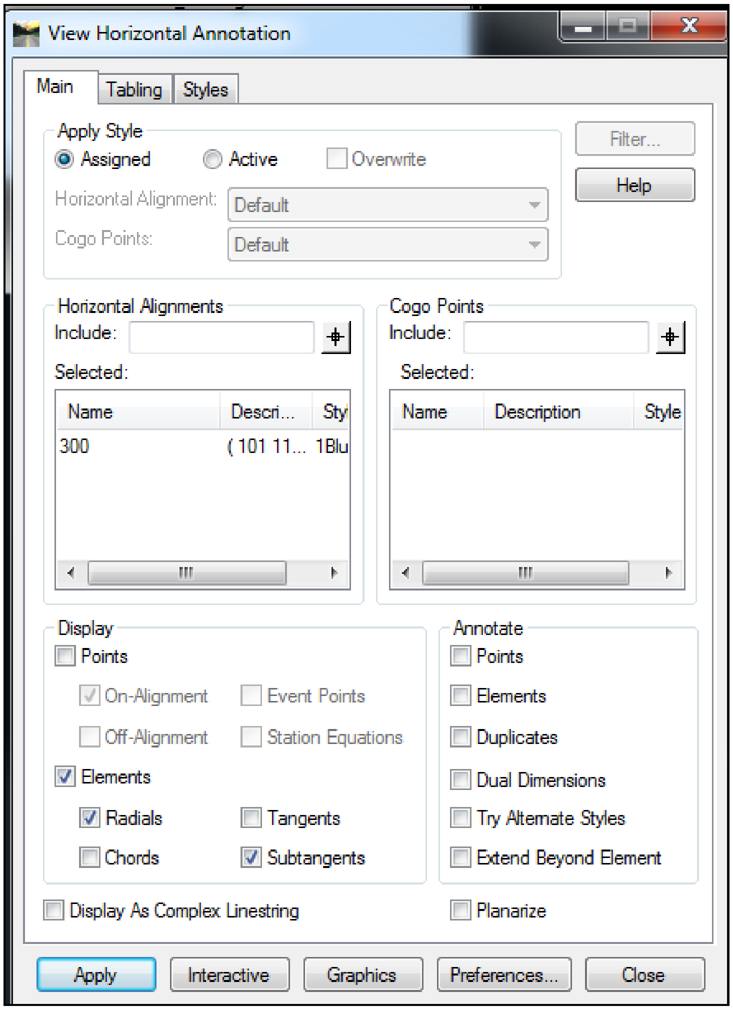
      ii. Select **Filter**

      iii. Select *300* under Available

      iv. Select *Add*



      v. OK



c. Apply

d. Observe the 3 center curve in the plan view

e. Close

4. Select **Geometry > Horizontal Element > Check Integrity**

   a. Review the alignment and note that the curve resolves the issue

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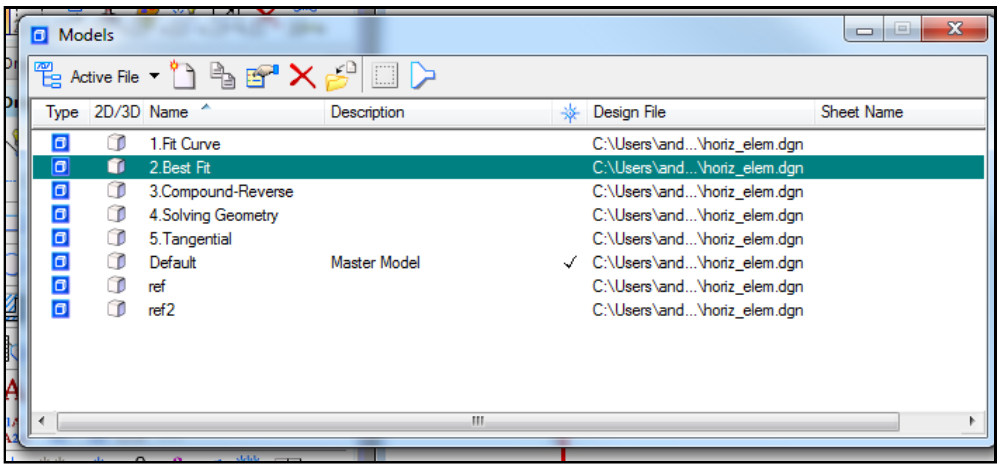
Chapter 2: Best Fit from Survey Centerline

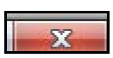
Chapter Objective:

In this unusual situation, x,y coordinates of a centerline have been given. However, only 24 points have been provided for a 4 mile stretch of roadway. It is required to create a best fit alignment with the points provided using the Geometry commands in Power InRoads. This is not a typical Regression workflow, but Regression tools will be used to solve for some of the Geometry.

Open Model

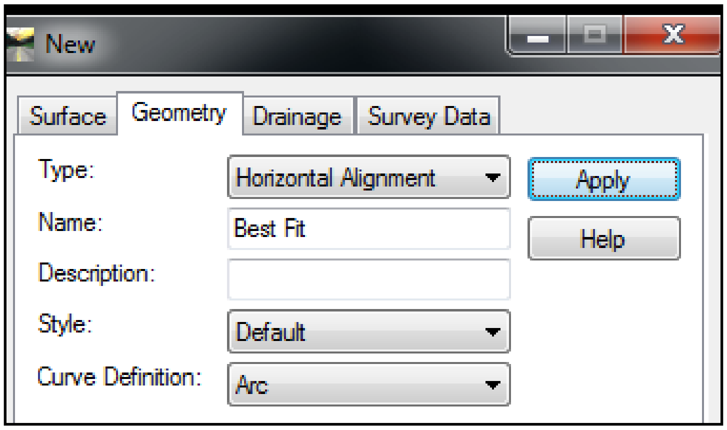
1. Click Models 
2. Double-click on *2.Best Fit* to activate that model



3. Close Models 

Create a New Alignment

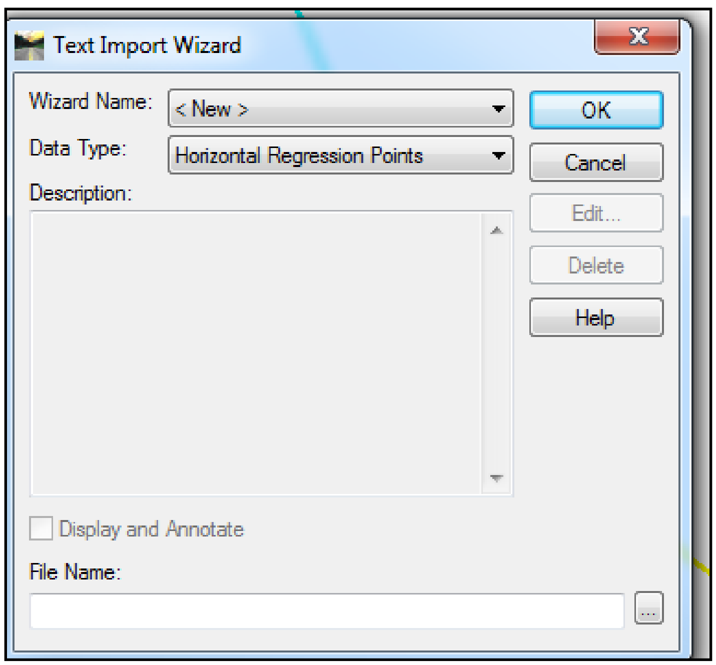
1. Select **File > Power InRoads File > New > Geometry**
   a. Set Type to *Horizontal Alignment*
   b. Key in *Best Fit* for the alignment name
   c. Apply



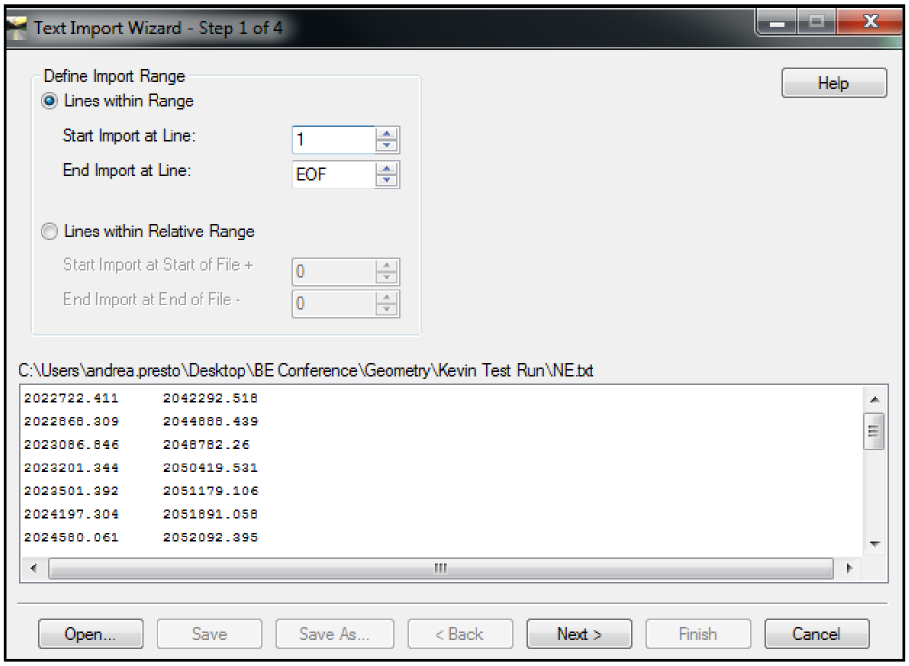
d. Close

Import Horizontal Regression Points

1. Select **File > Text Import Wizard**
   a. Select Data Type to be *Horizontal Regression Points*
   b. Navigate to the directory *C:\2012_BT_Civil\BC2WK2 - Advanced Geometrical Layout \Data\BC2WK2 Advanced Geometrical Layout \Best Fit* 



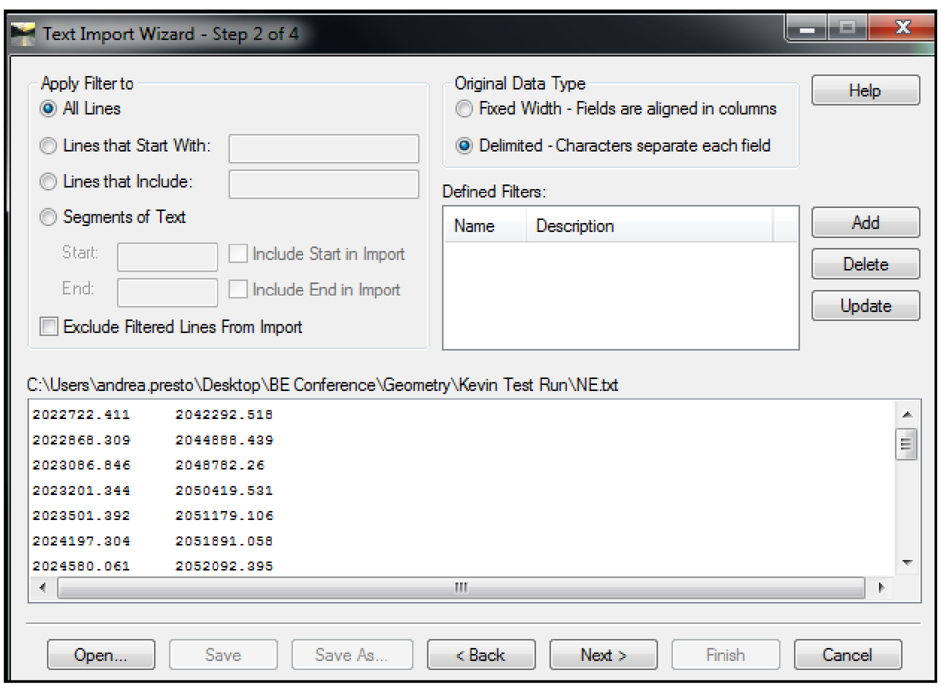
   c. Select the *NE.txt* file and click Open
   d. OK
2. Text Import Wizard – Step 1 of 4
   a. Keep the default settings in this first step (It will import lines 1 through the end of file)



b. Next

3. Text Import Wizard – Step 2 of 4

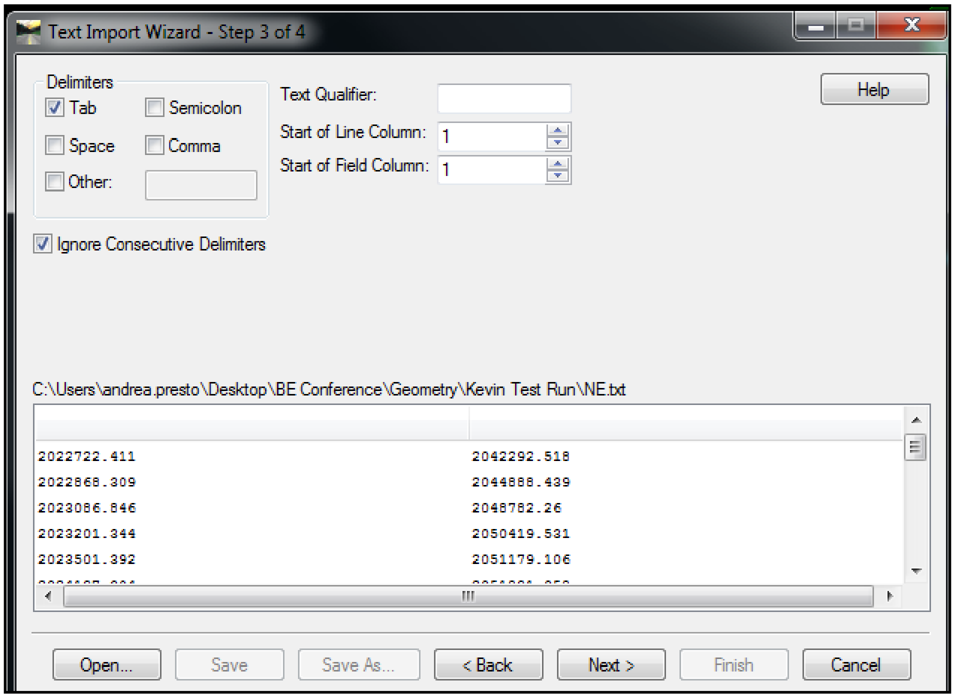
a. Again, keep the default settings in the second step. It will import all the lines to the file



b. Next

4. Text Import Wizard – Step 3 of 4

a. Select the Tab option as the delimiter for this specific file

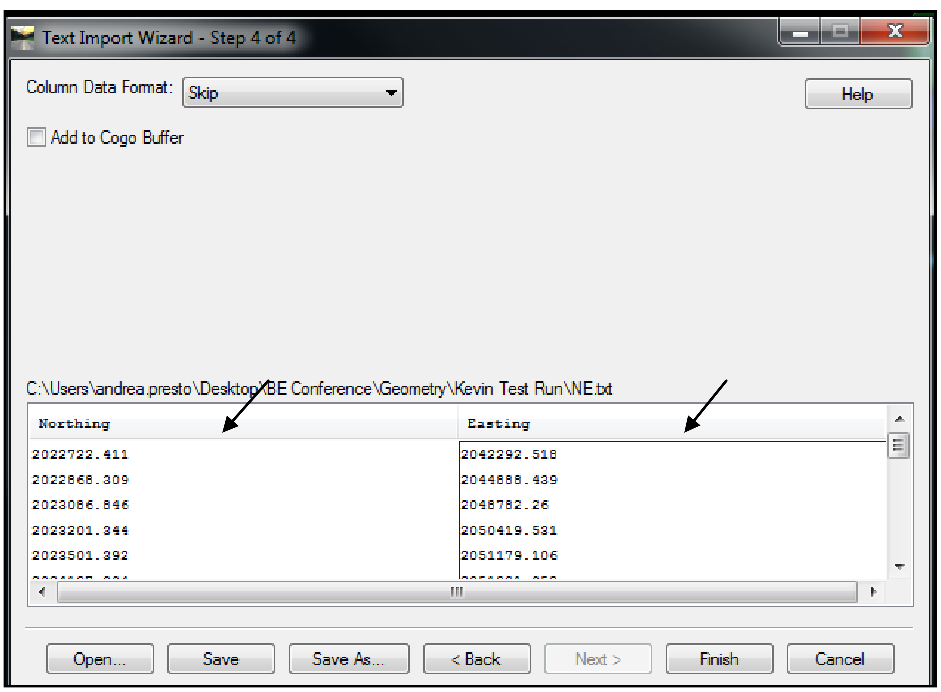


b. Next

5. Text Import Wizard – Step 4 of 4

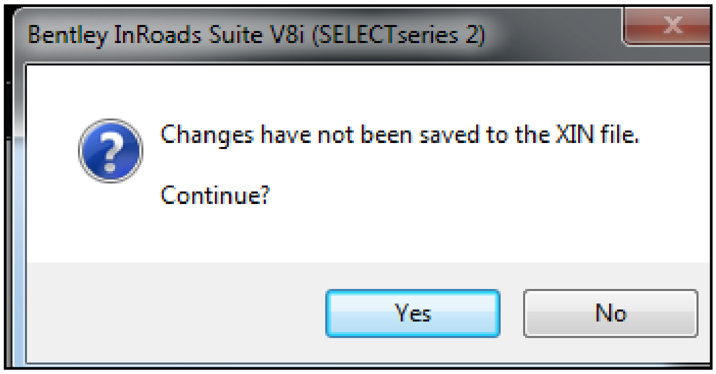
   a. Define the columns as Northing / Easting as shown in the picture below

Note	Right-click on the column header and select the correct value

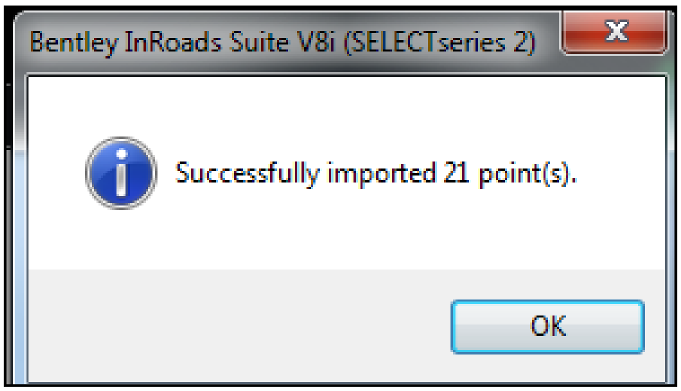


   b. Finish

6. Select *Yes* to the dialog with the following message: “Changes have not been saved to the XIN file. Continue?”



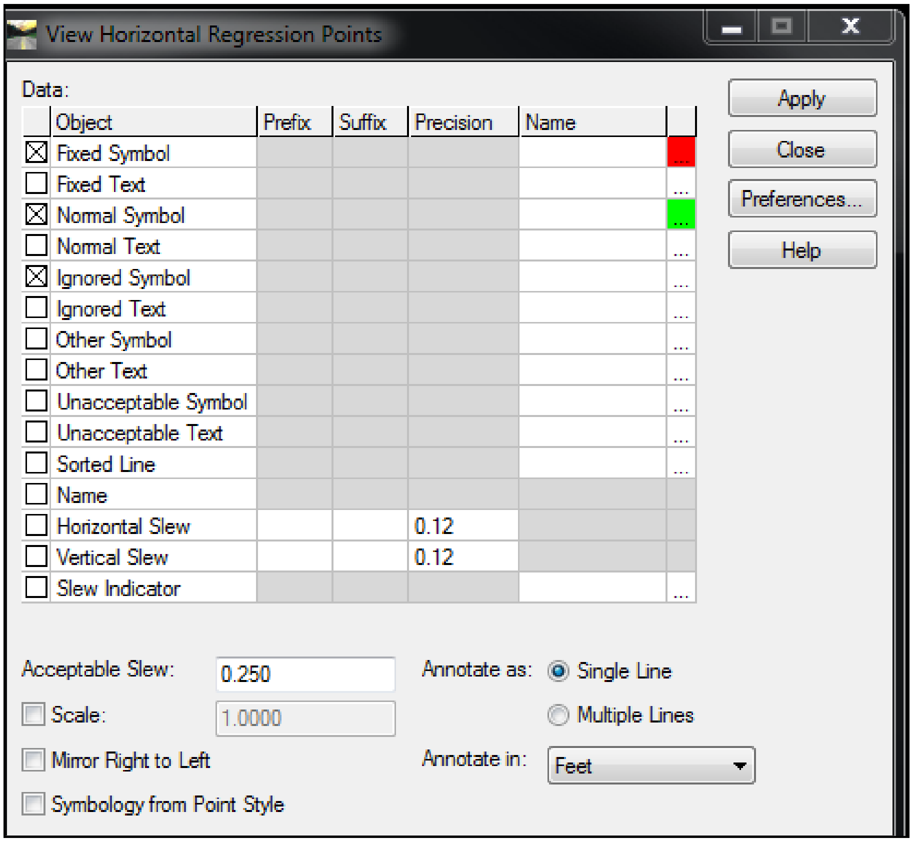
7. Select OK on the dialog that states the 21 points have been imported successfully



Note	Importing regression points by this method assumes that points are in order and that all points are valid. The typical regression sorting and ordering is not used in this context.

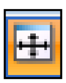
View the Horizontal Regression Points

1. Select **Geometry > Horizontal Regression > View Regression Points**
    a. Load Preference *Best Fit*



b. Apply

c. Close

2. Fit View 

Report Lock

1. Ensure Report Lock is turned on

   a. Select **Tools > Locks > Report** 

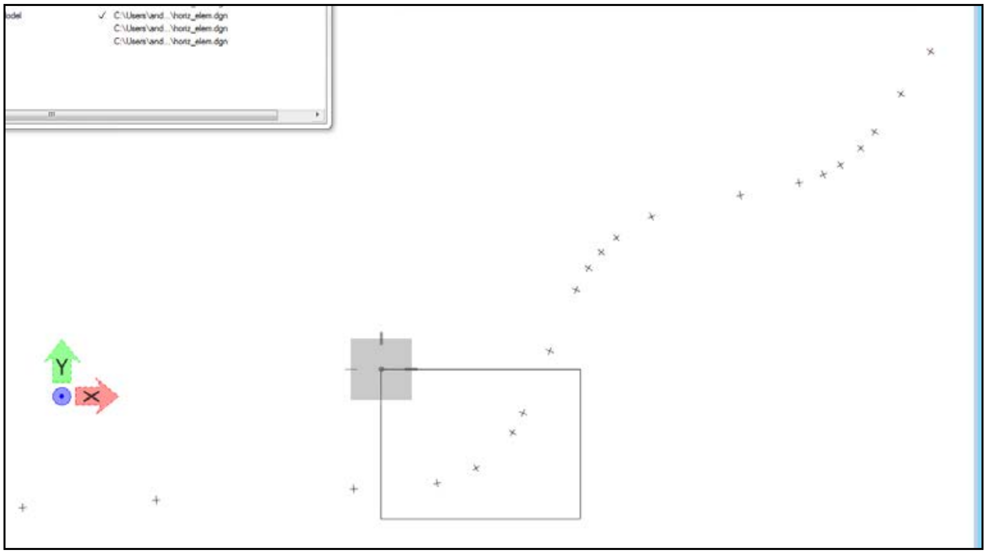
Note	Regress the 3 curves only to get their radii. Then delete the curve elements and add the curves back in after tangents have been defined.

Working with Regress Points

1. Select **Geometry > Horizontal Regression > Edit/Review Regression Points**

   a. Select the *Select & Regress* button

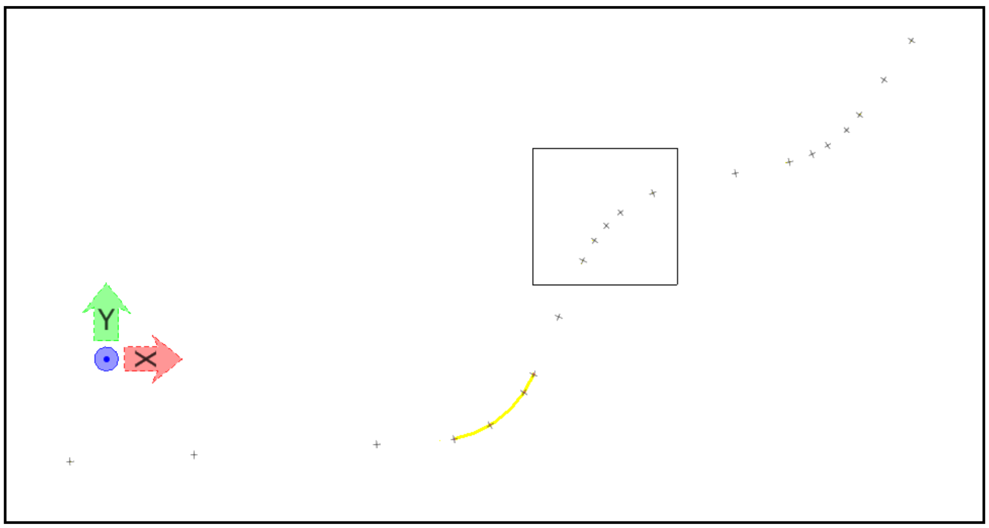
   b. Select the group of four points for the first curve starting from the left (See Screenshot)



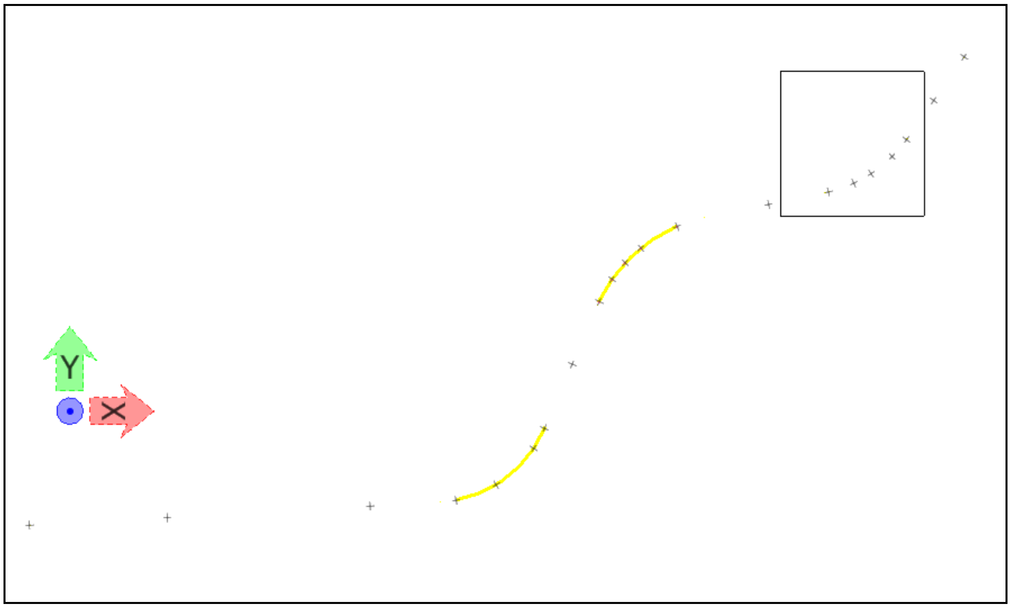
First group of selected points for first curve

c. For each Results dialog, write down the radius for each curve

d. Repeat for each curve as illustrated in the screenshots below

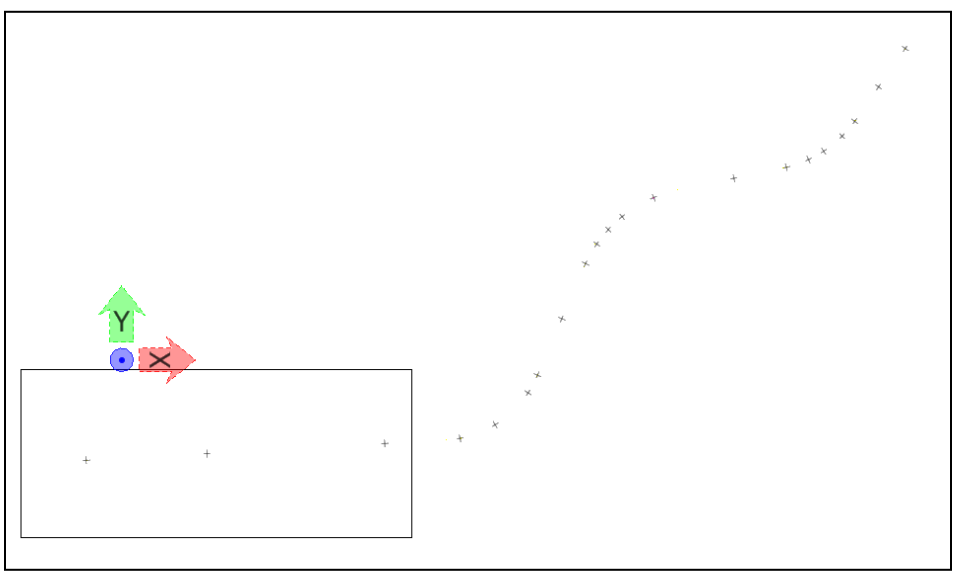


Second group of selected points for second curve



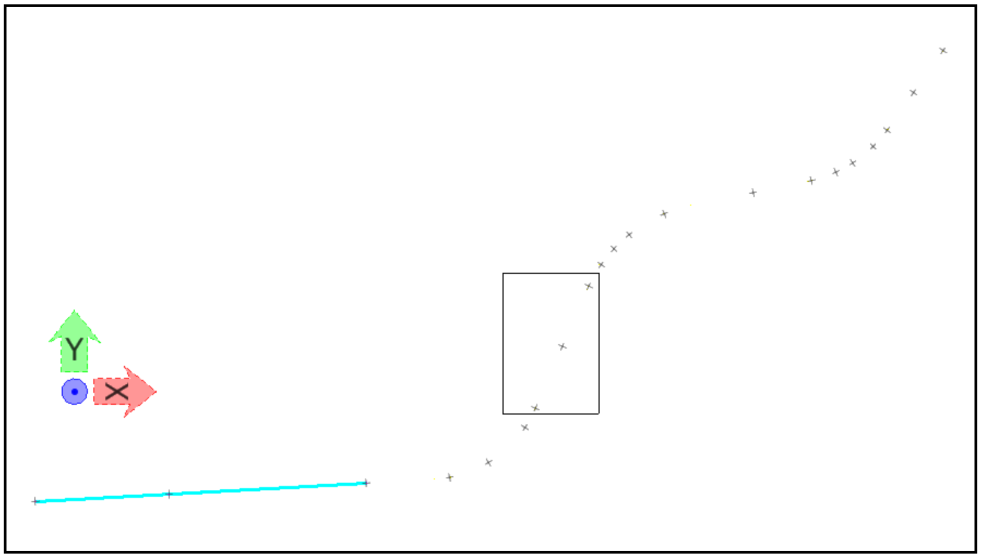
Third group of selected points for third curve

2. Select **Geometry > Horizontal Element > Delete Element**
   a. Use *Selected Element Only*
   b. Apply
   c. Delete the elements that were just created with the regression tool
   d. Data point to Accept the solution
   e. Reset and Close to exit the Delete Element command
3. Select **Geometry > Horizontal Regression > Edit/Review Regression Points**
   a. Select the *Select & Regress* button
   b. Select the group of three points for the first tangent from the left. (See Screenshot)

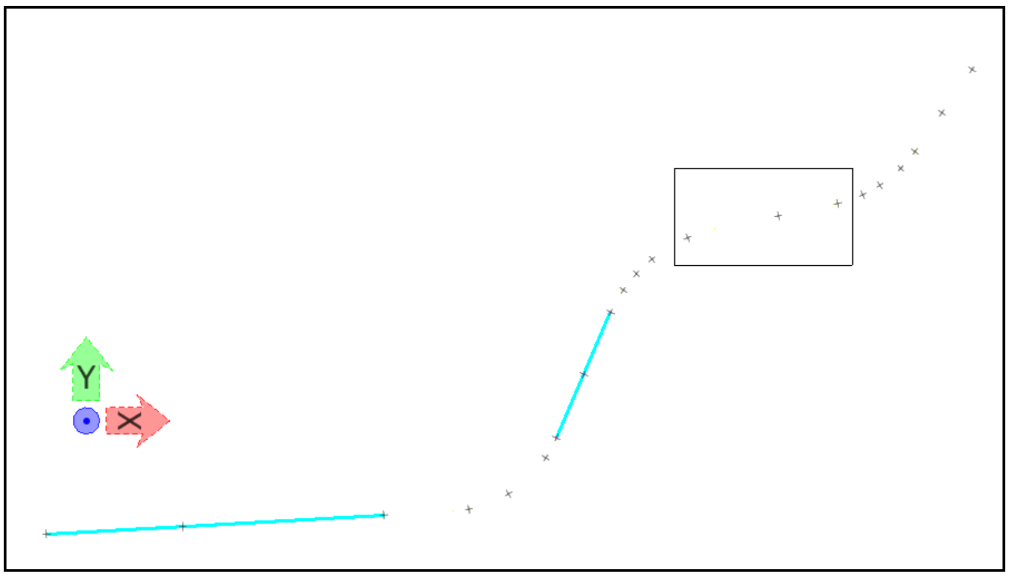


First group of selected points for first tangent

   c. For each Results dialog, make note of the offsets used during Regression to verify that the elements are valid.
   d. Repeat for each tangent as illustrated in screenshots below



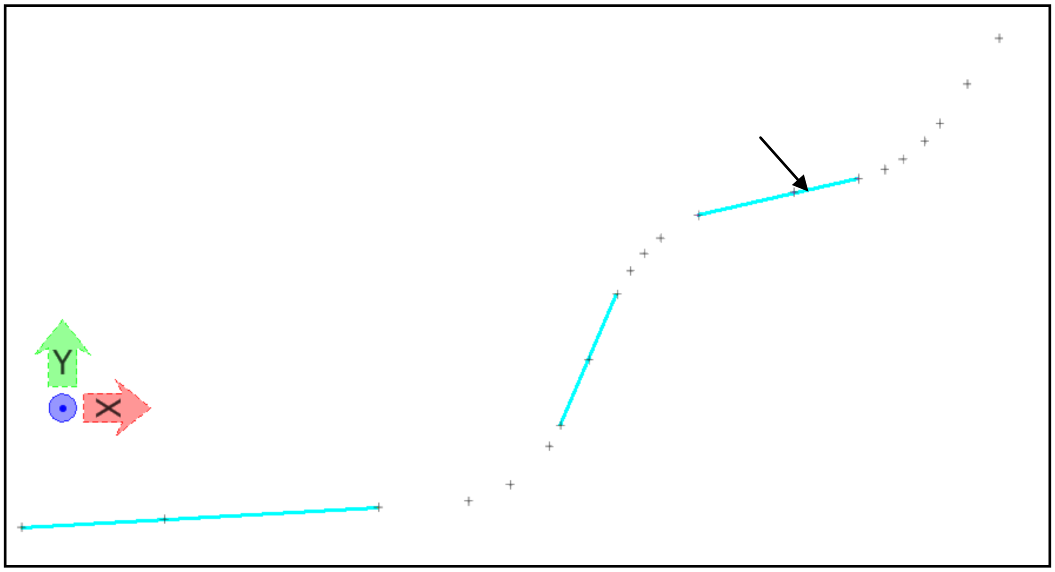
Second group of selected points for second tangent



Third group of selected points for third tangent

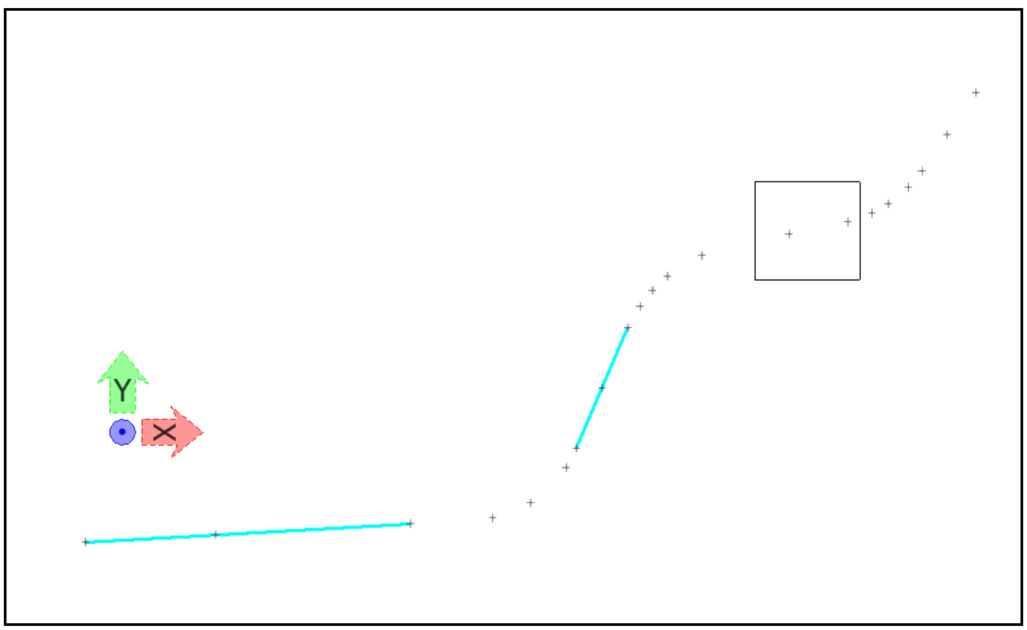
Note	Note the large offset of points. Delete this element and recreate with two points.

4. Delete any element that is not valid
   a. Select **Geometry > Horizontal Element > Delete Element**



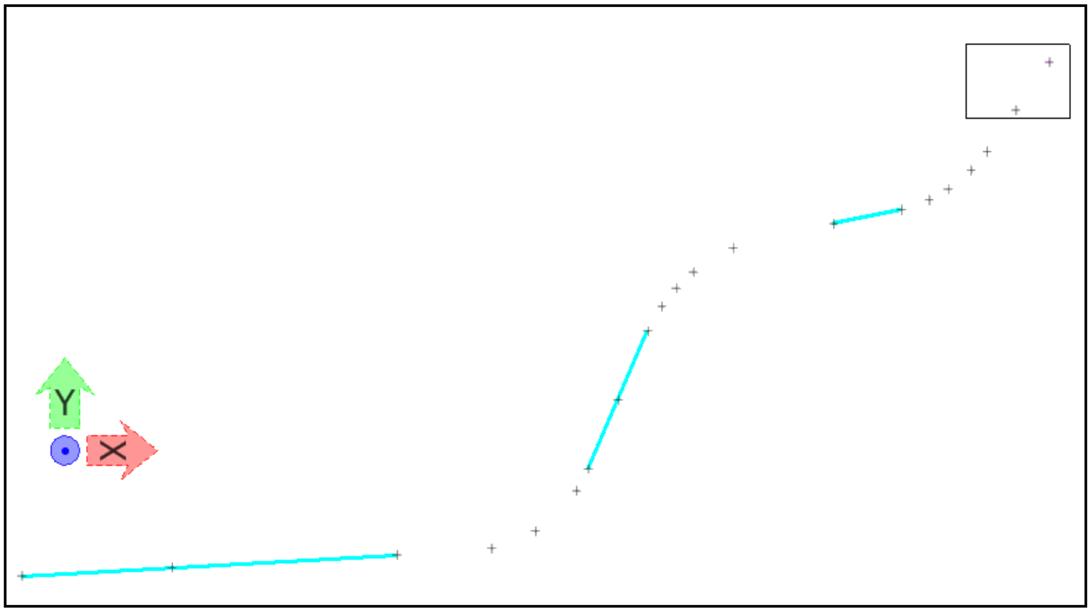
Select tangent to delete

5. Recreate the third tangent by selecting two points instead of three
   a. Select **Geometry > Horizontal Regression > Edit/Review Regression Points**



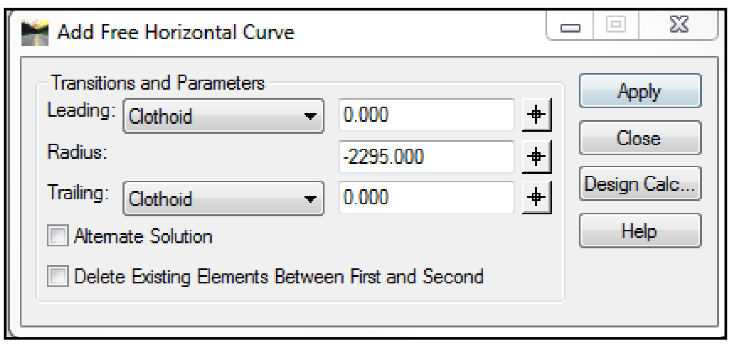
Group of selected points for third tangent

6. Continue with the last tangent
   a. Select **Geometry > Horizontal Regression > Edit/Review Regression Points**

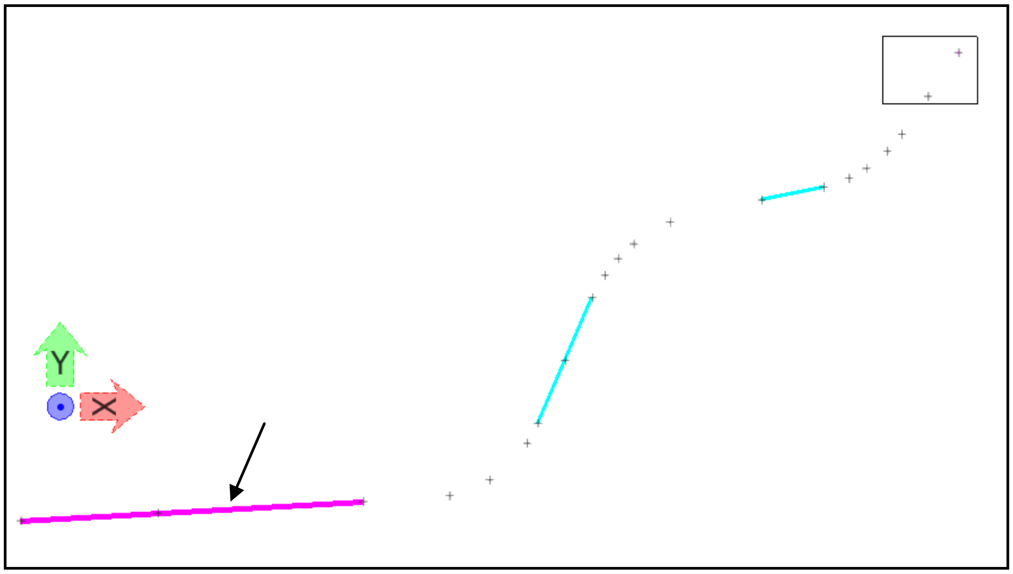


Forth group of selected points for forth tangent

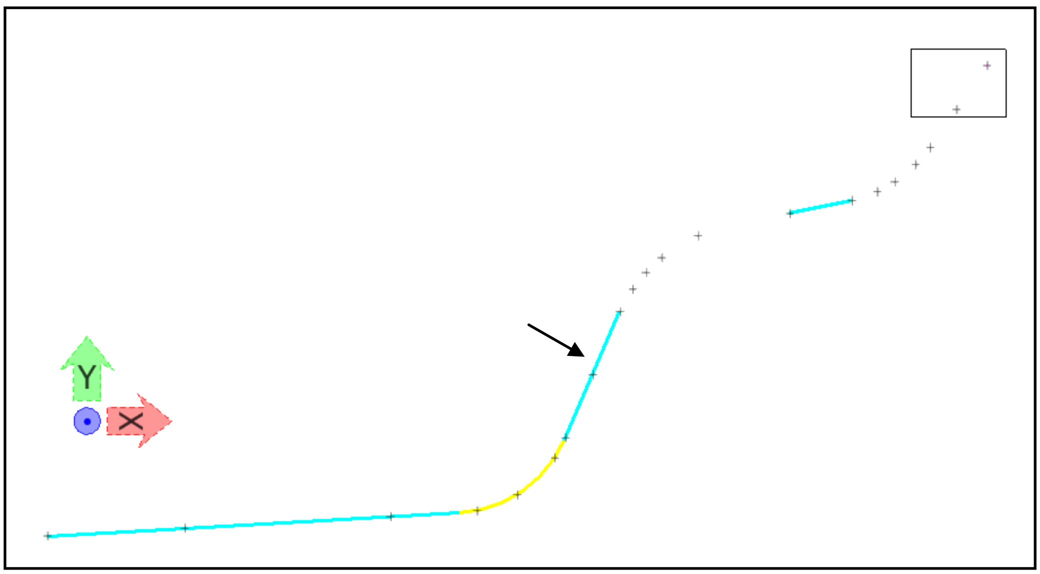
7. Select **Geometry > Horizontal Elements > Add Free Curve**
   a. Use the radii from previous workflow above to add in curves (Left curves will require a negative sign)



   i. Apply
   ii. Add first curve by selecting first and second tangents



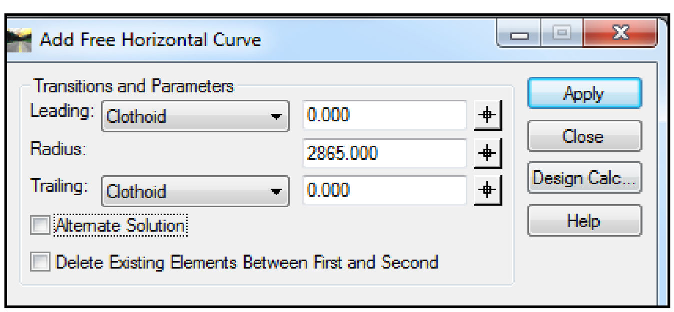
First Tangent

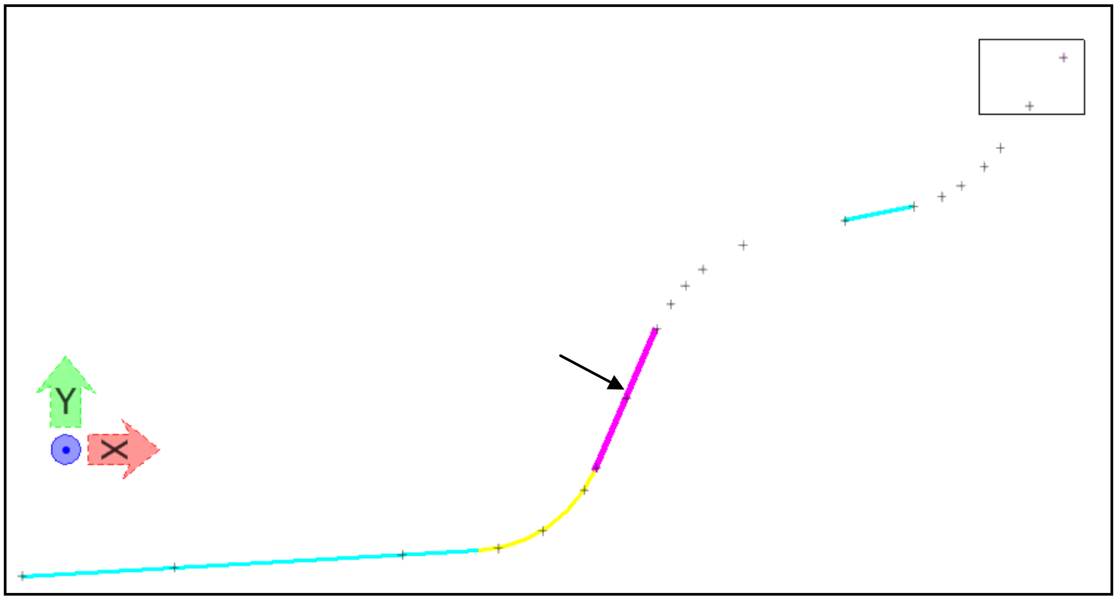


Second Tangent

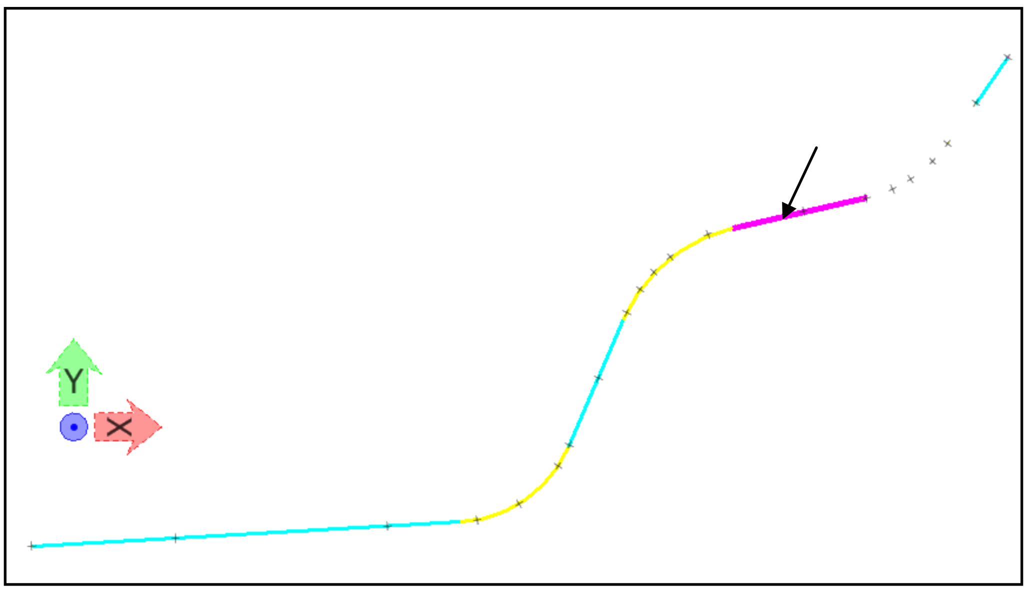
b. Reset to bring up the dialog to change the radius

c. Repeat for next two curves

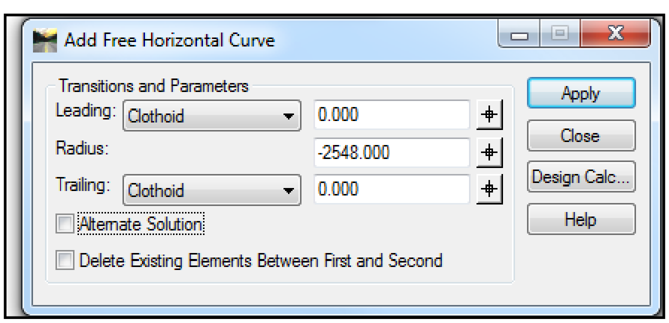


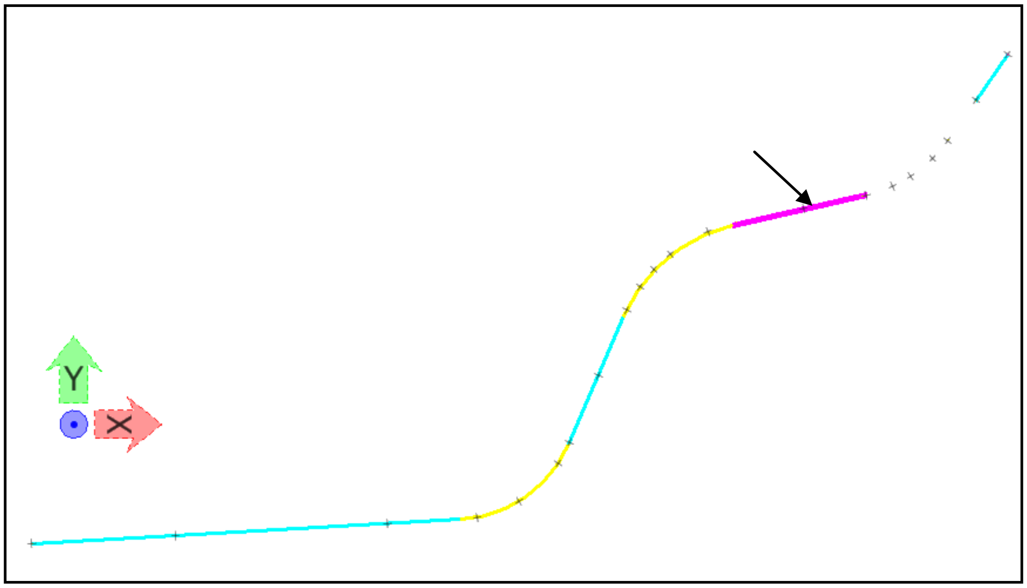


Second Tangent

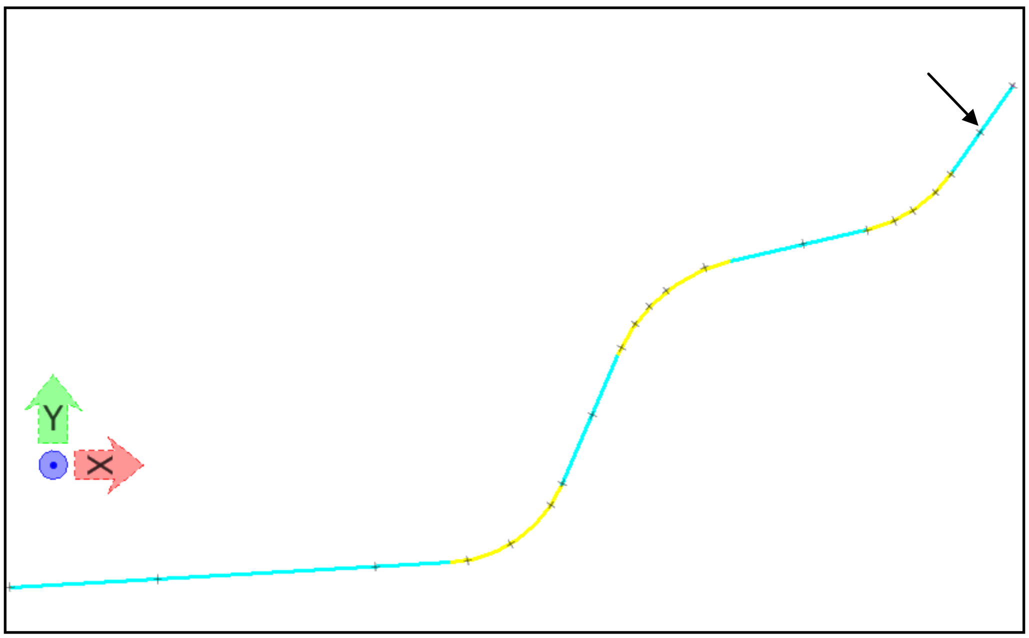


Third Tangent



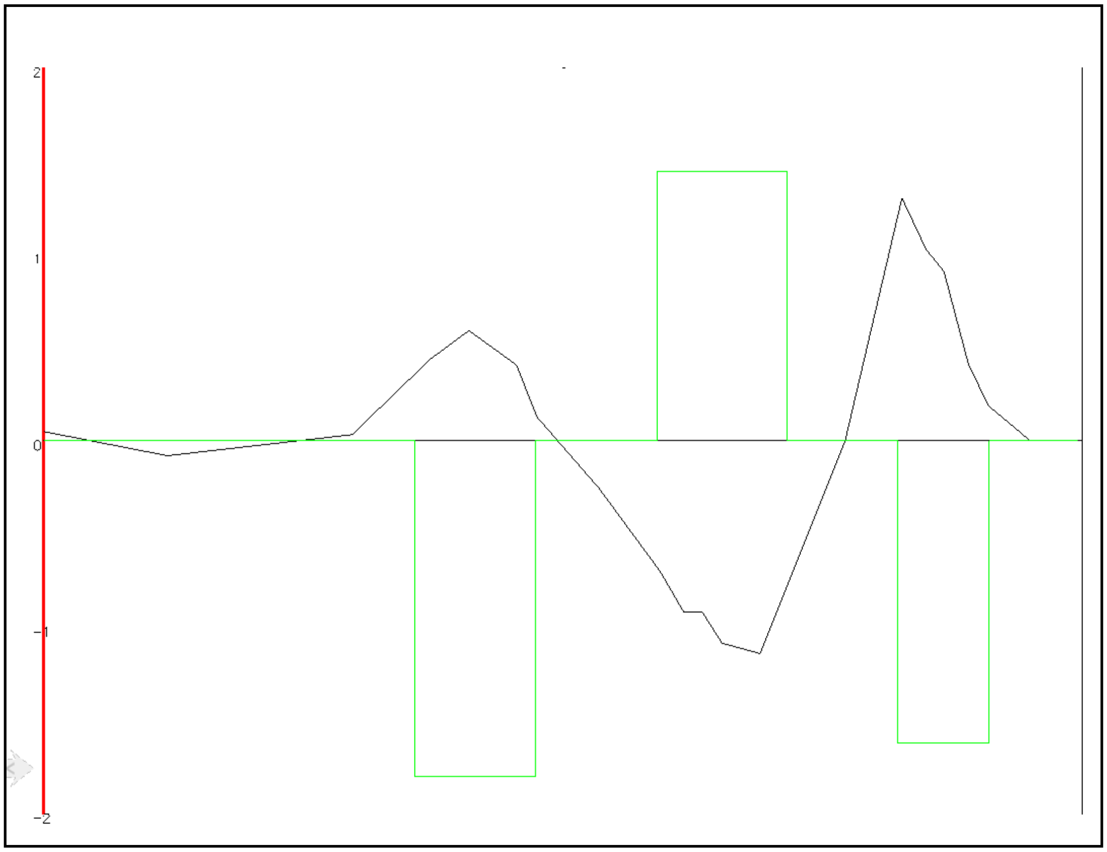


Third Tangent



Forth Tangent

8. Select **Geometry > Horizontal Regression > Slew Diagram**
    a. Load *Best Fit* preference
    b. Apply
    c. Data point to select a location in the design file to place the slew diagram



Slew Diagram

d. To view slew information in an XML report, click Report

Note	The maximum offset from the surveyed points to the alignment is about 1.3

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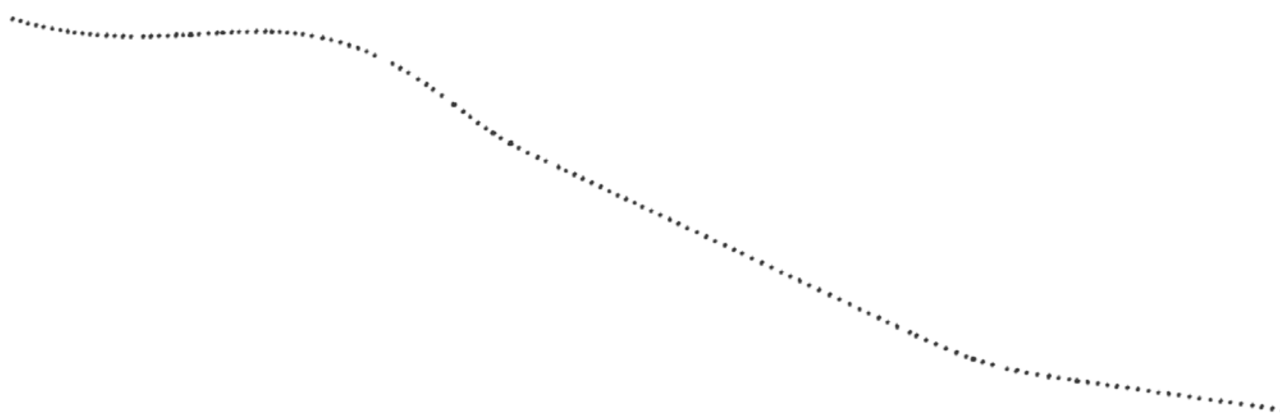
Chapter 2 Alternate: Horizontal Regression from Survey Centerline

CHAPTER OBJECTIVES

Many times a user is provided a survey consisting of coordinates that represent the centerline of an existing road or rail. The user is required to quickly create a curvilinear alignment consisting of lines, circular arcs and transition spirals. In this chapter we will discuss functionality that will aid the user in creating the curvilinear geometry.

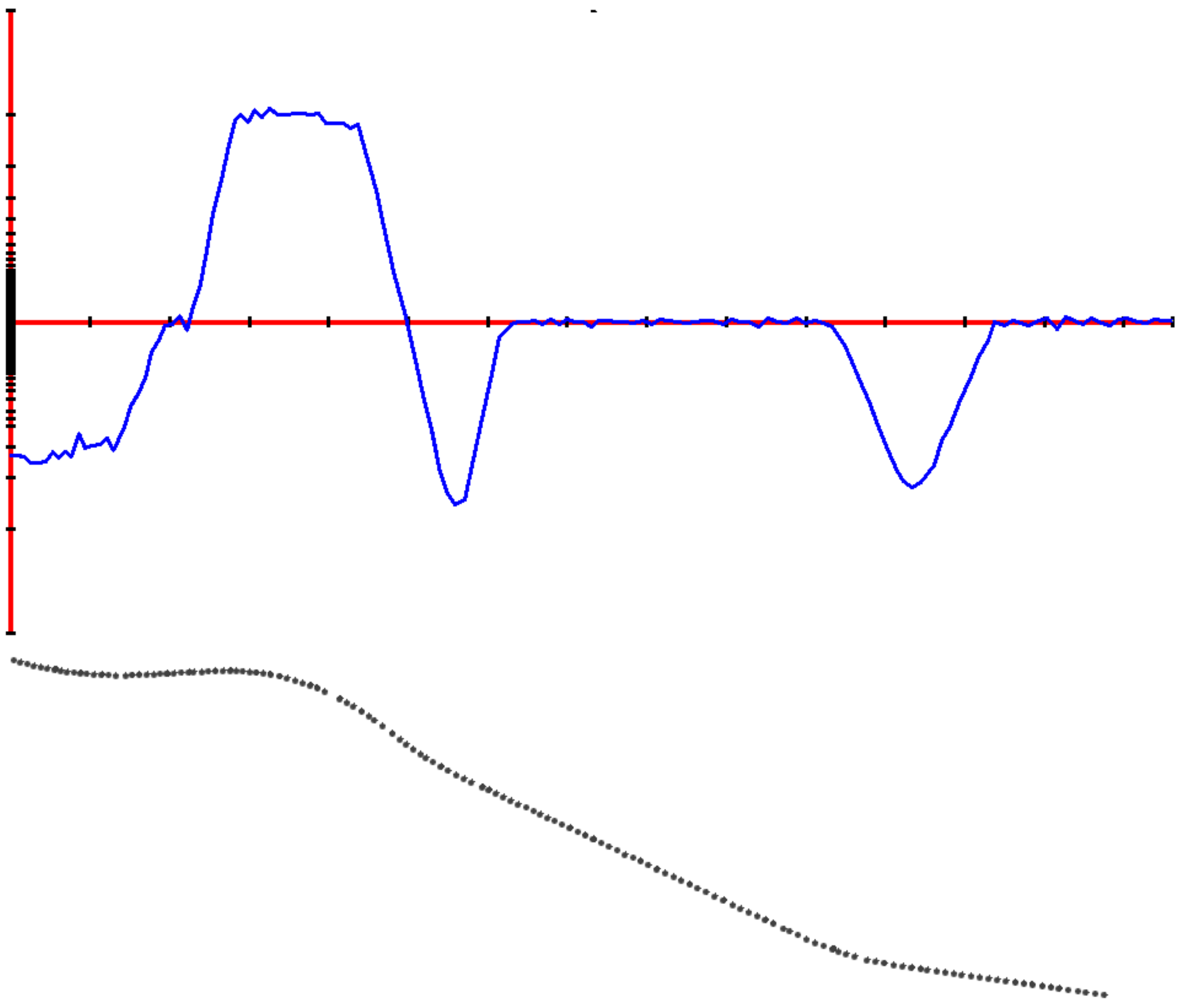
PROCEDURE

1. Create a new .dgn
1. Open the file *shortened.alg*
2. Open the file *regression.xin*
3. Go to ***Horizontal Regression > View Regression Points*** and click *Apply*
4. Fit the view and let's look at the data



It appears that we have four circular arcs and two maybe three tangents. The leftmost circular arcs can be readily picked out from the data, the third is a bit more difficult and the fourth circular arc is detectable. But, does the data indicate whether or not there are any transition spirals? Or can the user determine if there is any questionable data? When the answer is obviously, no! You can't detect transition spirals or bad data. And if you really thought about it, you would have difficulty detecting the start and end of circular arcs. Let's see what can be done to resolve this.

5. Go to ***Horizontal Regression > Horizontal Curvature Diagram*** and click *Apply*
6. At the prompt *Identify Location*, data point slightly above the points.



What does this diagram tell use? The curvature diagram allows the user to display 1 / R in the y-axis and the length along in the x-axis. The following:

- If the point data runs close to the x-axis then those points will represent a line.
- If the point data runs nearly parallel but offset from the x-axis then those points will be represent a circular arc
- If the point data is neither of the above then those points will be a transition spiral.

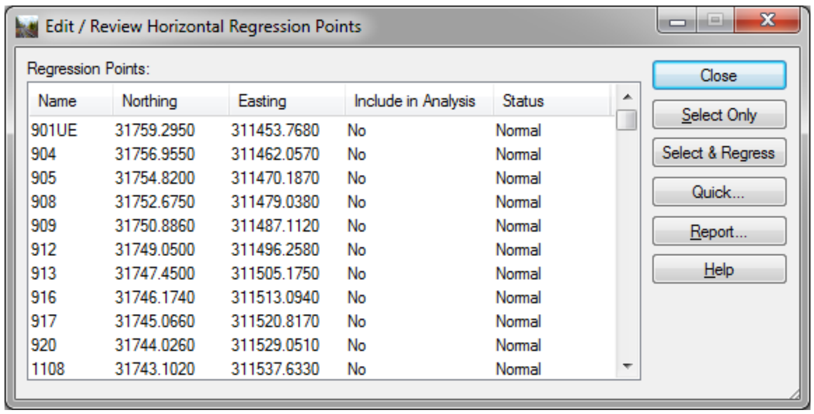
What else can be seen from the diagram? If you see a spike in the curvature line then that point may be a bad point and you may wish to ignore it. In our case all of the points are reasonable.

Let's discuss the workflow to regress these points. We will do the following:

- From the diagram, we will work from left to right and select and regression the obvious lines and circular arcs. We will use ***Horizontal Regression > Edit Review Regression Points***
- In fill transition spirals between the lines and circular arcs. We will use ***Horizontal Element > Define Spiral***

But first a discussion on selecting points for the individual lines and circular arcs. It should be clear that at a minimum, we need two points for a line and three points for a circular arc. And when we select points, we only want to select points that are within the extents of the line or circular arc. You may ask, should I try to include the points that represent the exact start or end of an element? No, you should not! Why not? Well in doing so, you may actually be selecting points that are within the extents of another element. So when we regress the points, we may artificially skew the results. So it is best practice to not attempt to include the start and end points of an element.

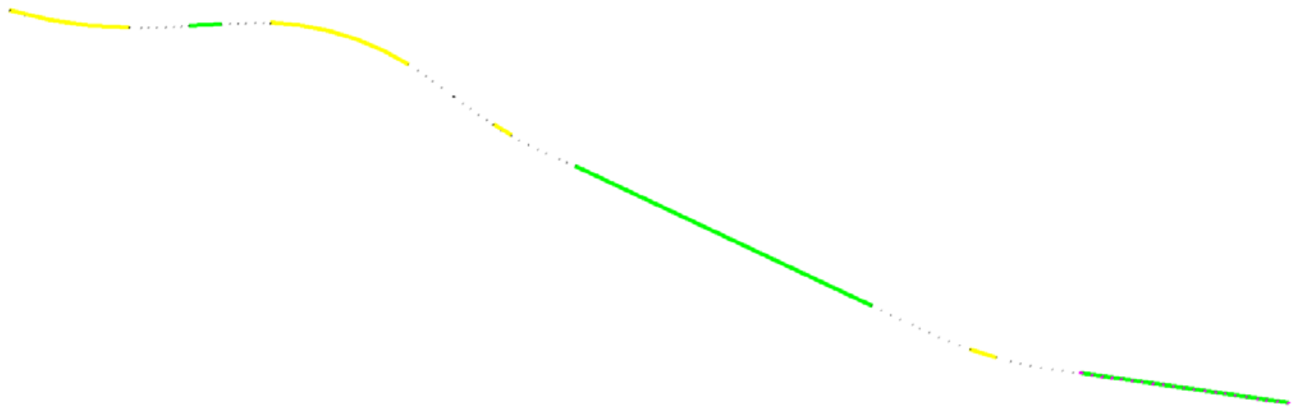
7. Go to ***Horizontal Regression > Edit Review Regression Points*** and click *Select & Regress*



8. For each line and circular arc, we will repeat the following steps
   - *Identify first point*
   - *Identify second point*
   - *Accept / reject*

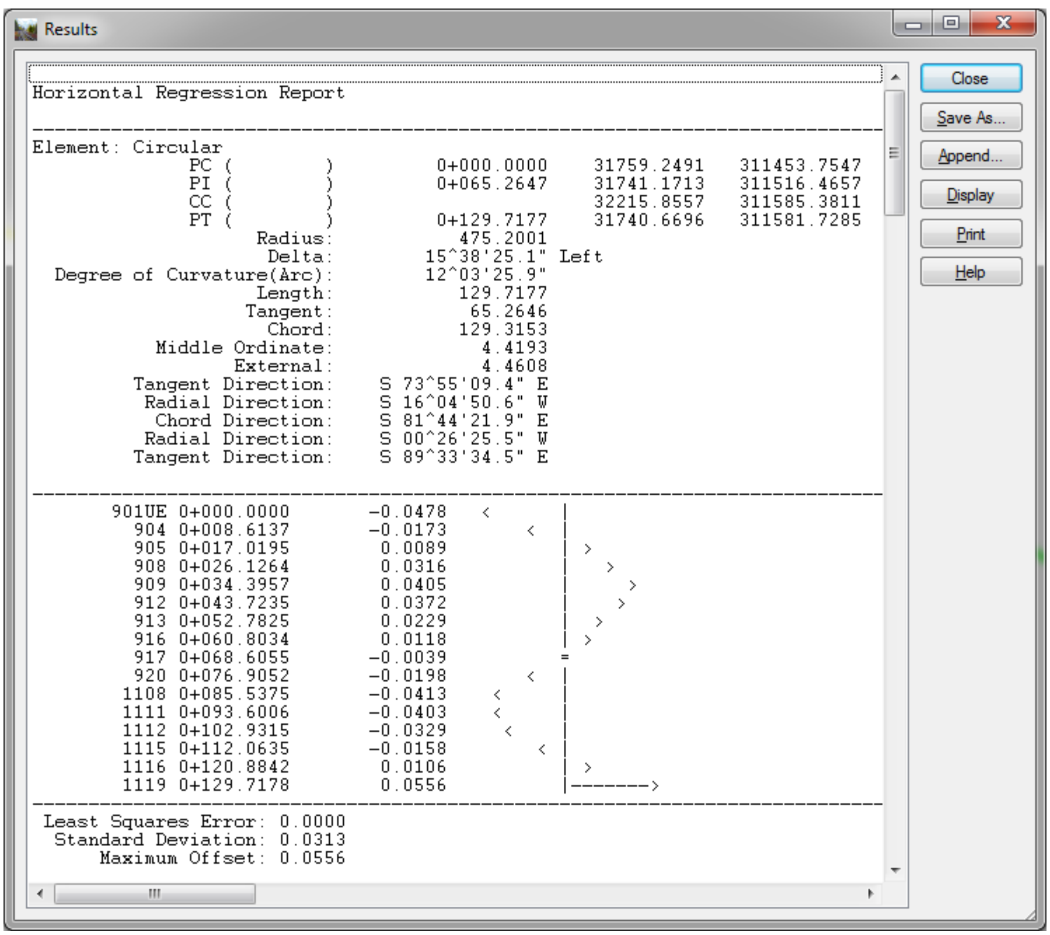
Note	We will be using the curvature diagram to select the lines and circular arcs. Also, if you check on ***Tools > Locks > Report***, you will get textual data, which will provide details on the results of the regression analysis.

When you have completed this step you should have the following:



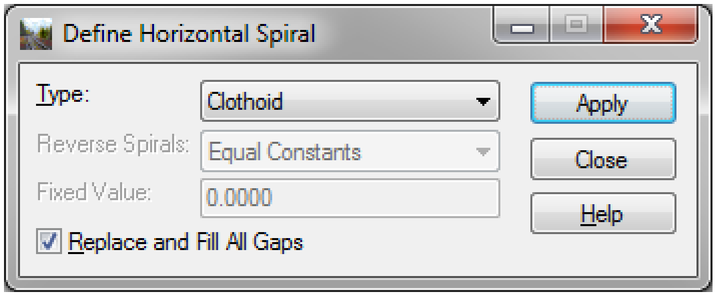
With the above results, how close are we to our original guesses? We did not detect the first line between the first two circular arcs. The two short arc circulars we detected, but it would have been difficult to find them without the curvature diagram.

Also, if you had checked on report lock, you would have the following:



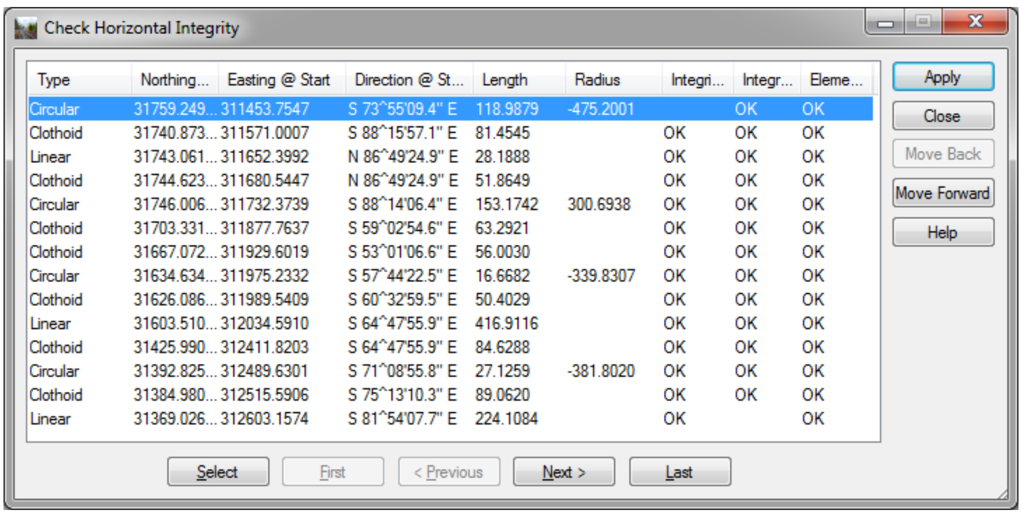

```
Horizontal Regression Report
------------------------------------------------------------------------------
Element: Circular
              PC (         )          0+000.0000    31759.2491    311453.7547
              PI (         )          0+065.2647    31741.1713    311516.4657
              CC (         )                        32215.8557    311585.3811
              PT (         )          0+129.7177    31740.6696    311581.7285
                    Radius:            475.2001
                     Delta:          15^38'25.1" Left
  Degree of Curvature(Arc):          12^03'25.9"
                    Length:            129.7177
                   Tangent:             65.2646
                     Chord:            129.3153
           Middle Ordinate:              4.4193
                  External:              4.4608
         Tangent Direction:        S 73^55'09.4" E
          Radial Direction:        S 16^04'50.6" W
           Chord Direction:        S 81^44'21.9" E
          Radial Direction:        S 00^26'25.5" W
         Tangent Direction:        S 89^33'34.5" E
------------------------------------------------------------------------------
       901UE 0+000.0000          -0.0478    <       |
         904 0+008.6137          -0.0173        <   |
         905 0+017.0195           0.0089            | >
         908 0+026.1264           0.0316            |   >
         909 0+034.3957           0.0405            |     >
         912 0+043.7235           0.0372            |    >
         913 0+052.7825           0.0229            |  >
         916 0+060.8034           0.0118            | >
         917 0+068.6055          -0.0039            =
         920 0+076.9052          -0.0198        <   |
        1108 0+085.5375          -0.0413     <      |
        1111 0+093.6006          -0.0403     <      |
        1112 0+102.9315          -0.0329      <     |
        1115 0+112.0635          -0.0158         <  |
        1116 0+120.8842           0.0106            | >
        1119 0+129.7178           0.0556            |------->
------------------------------------------------------------------------------
 Least Squares Error: 0.0000
  Standard Deviation: 0.0313
      Maximum Offset: 0.0556
```

9. Okay, now let's add the transition spirals. Go to ***Horizontal Elements > Define Spiral***. Check on *Replace and Fill All Gaps* and click *Apply*



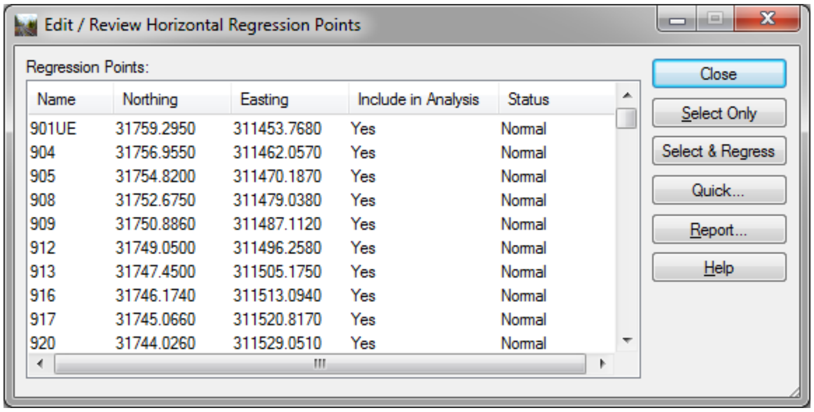
- At the *Identify first element*, select the leftmost circular arc
- At the *Identify last element*, select the rightmost line
- *Accept / reject* the solution

10. We now have an alignment with regressed lines and circular arcs and in filled transition spiral. Go to ***Horizontal Elements > Check Integrity*** to review the results

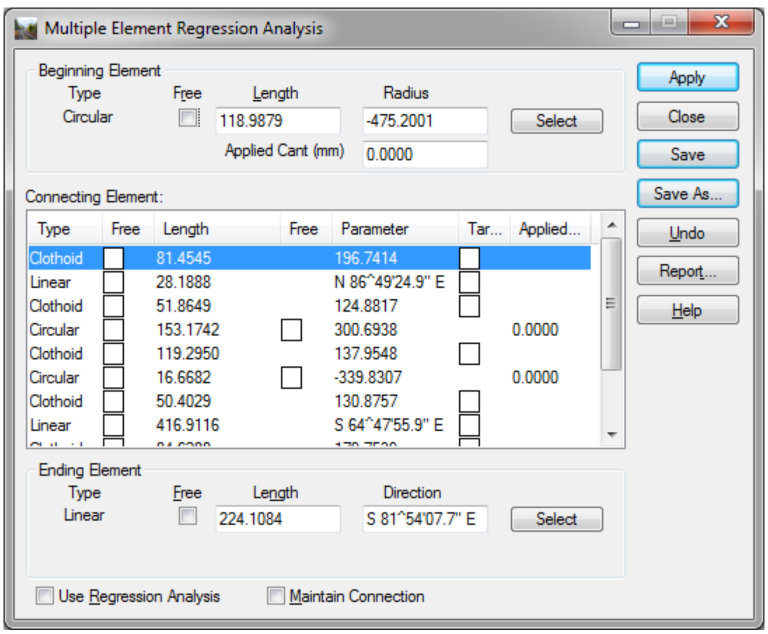


Note	If you want to control the content of the Check Integrity list-view, right click in the header and select / de-select what you want to see. You can also resize the columns and dialog so that it does not consume the entire monitor!

11. Go to ***Horizontal Regression > Edit Review Regression Points*** and click *Select Only* and place a rectangular around all of the points. This will include all points in the analysis.



12. Go to ***Horizontal Regression > Multi-element Regression Analysis*** and lets fine tune the results

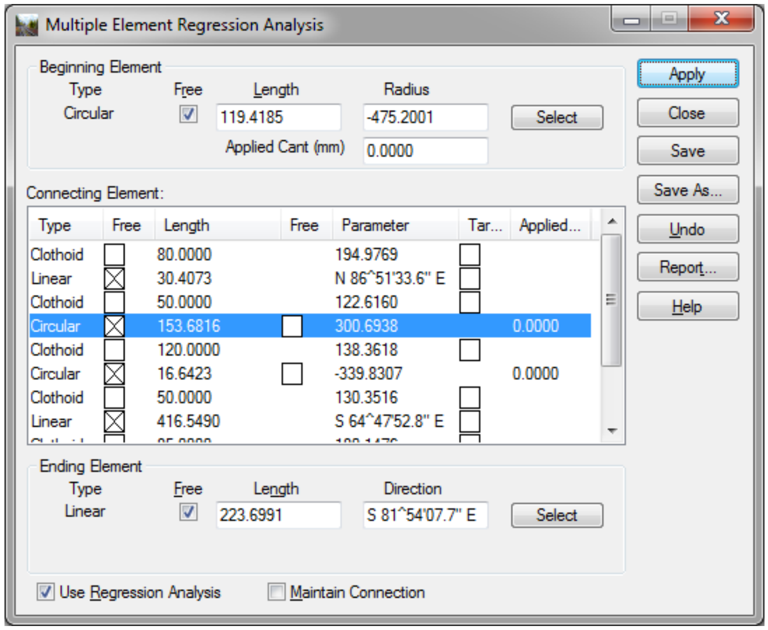


Select each element in the *Connecting Elements* list-view and for each transition spiral, round its length up or down to the nearest 5 meter interval.

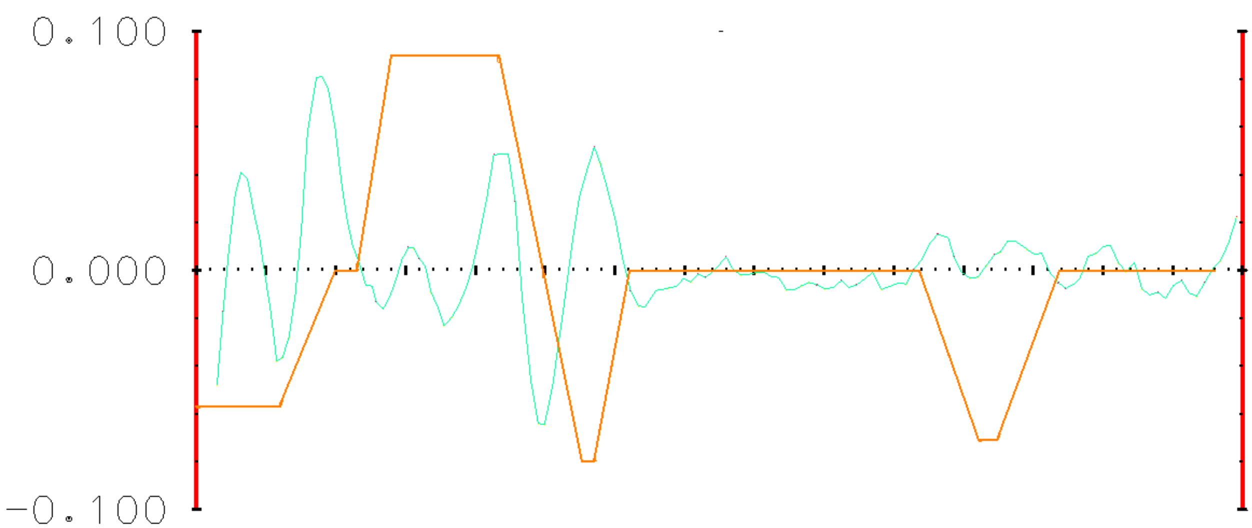
Also, set each linear element's length as free

Also, set each circular arcs element's length as free

As well as the *Beginning Element* and *Ending Element*

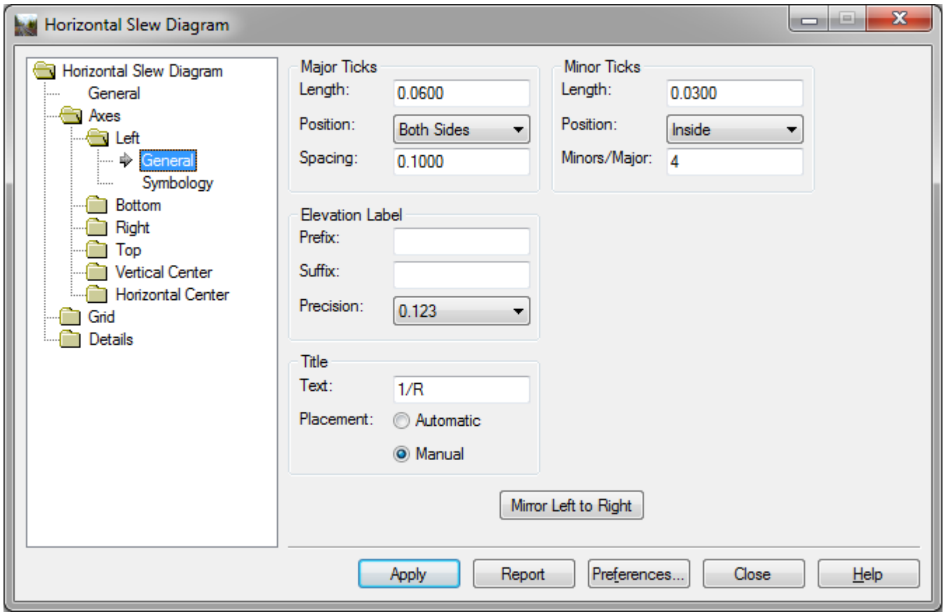


13. Check on *Use Regression Analysis*
14. Click *Apply*
15. Now edit each circular arc's radius so that it is rounded to the nearest 1 meter.
16. Once again click *Apply*
17. To review the results, click *Report…*
18. Go to ***Horizontal Regression > Slew Diagram***



We want the green line as close as possible to the x-axis. Obviously, real world data will never hit flat on the axis, so some amount of offset is acceptable.

What is the secret to getting a reasonable display? It has to do with the settings for the *Left Axes*. The *Major Spacing* should be something like 0.1 meters. And the *Elevation Label Precision* should be something like 0.123



Chapter Summary

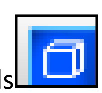
We have used **Regression Analysis** on survey points and have created a curvilinear alignment consisting of lines, circular arcs and transition spirals.

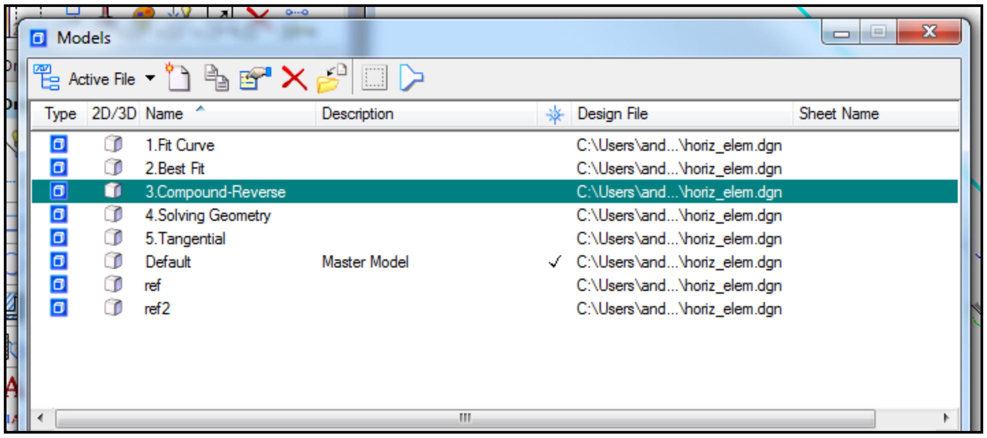
Chapter 3: Compound Curves

Chapter Objective:

In this lesson, the radius of the centerline does not fall between the existing edges of pavement. The alignment appears to need a flatter curve at the top of the arc while having a tighter curve at the lower end of the arc. This alignment requires a compound curve instead of the one single curve that was initially created with the PI tools.

Open Model

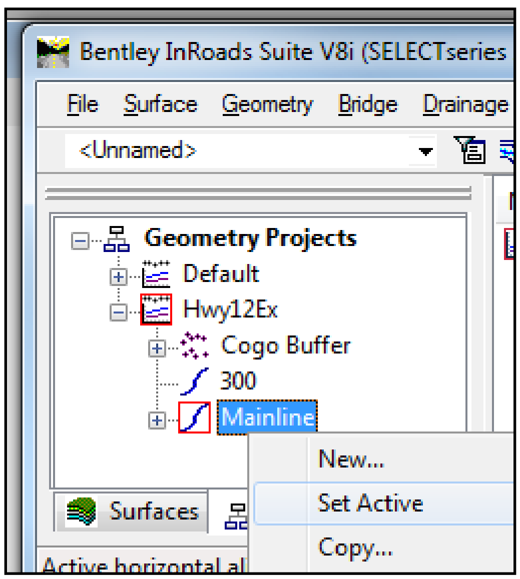
1. Click Models 
2. Double-click on *3.Compound-Reverse* to activate that model



3. Close Models 

View and Review Horizontal Alignment

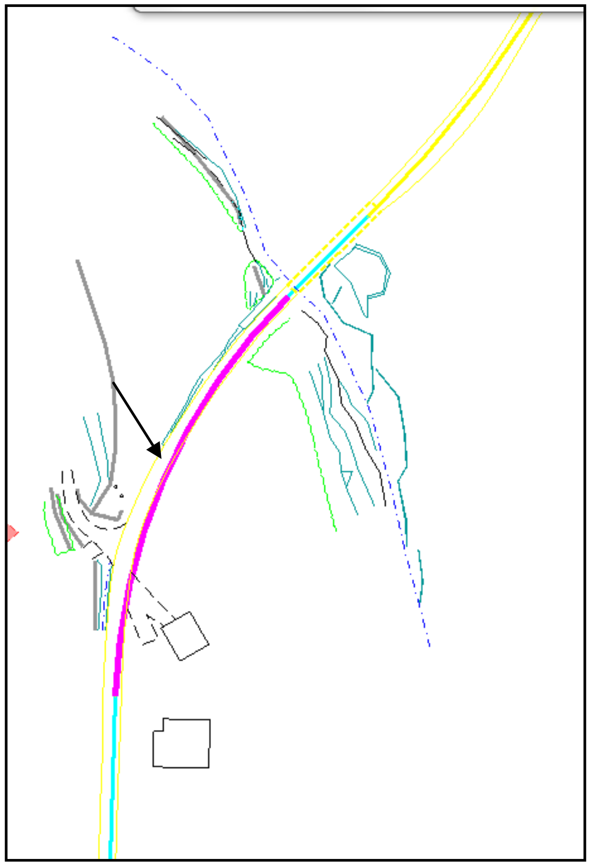
1. Set *Mainline* alignment active
   a. Right click on *Mainline* in InRoads and select *Set Active*



2. Select **Geometry > View Geometry > Active Horizontal**
3. Select **Geometry > Review Horizontal**
   a. Set mode to Element
   b. Select "Next" to view first curve
   c. Make note of the radius of the alignment's first curve

Edit Alignment

1. Select **Geometry > Horizontal Element > Delete Element**
   a. Select option *Selected Element Only*
   b. Apply
   c. Select the first curve of the alignment

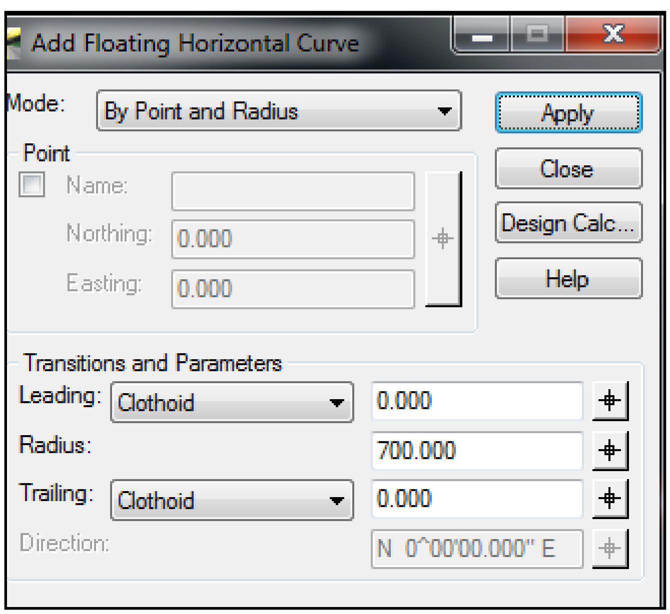


Delete Element

d. Reset and Close to exit the Delete Element command

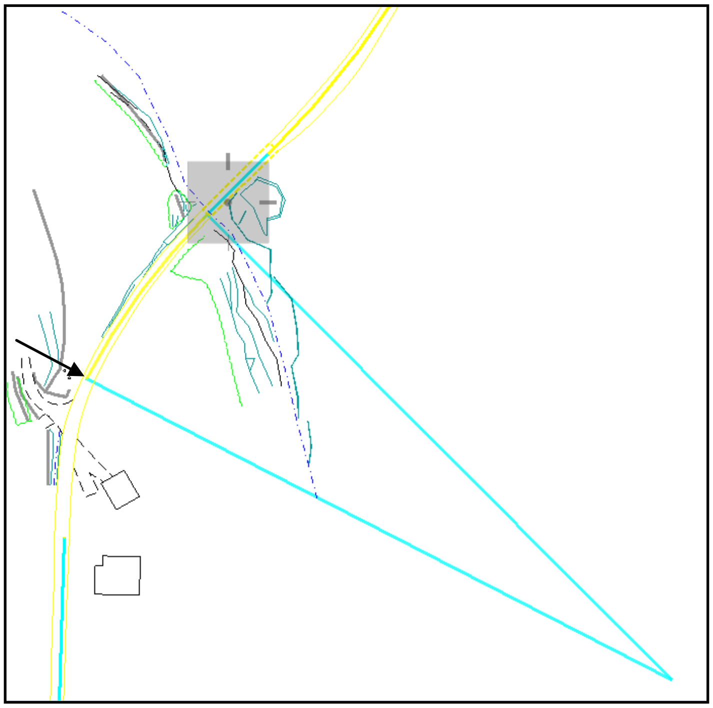
2. Select **Geometry > Horizontal Element > Add Floating Curve**

a. Set the radius to 700



b. Apply

c. Select second tangent and float the curve out so that it is between the two edges of pavement (See Screenshot)



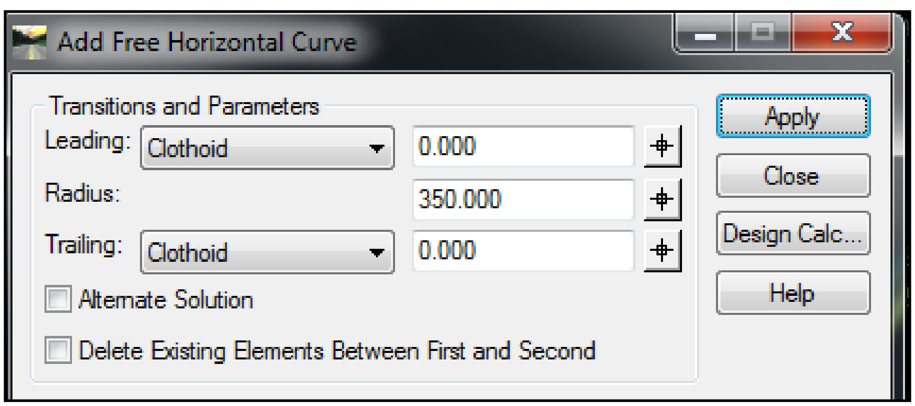
Float Curve out to center of EOPs

d. Data point to Accept the solution

e. Reset and Close to exit the Add Floating Horizontal Curve command

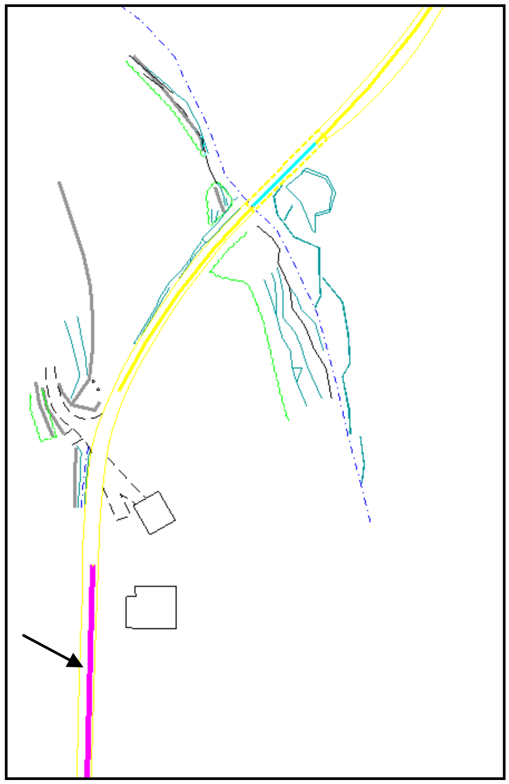
3. Select **Geometry Horizontal Element > Add Free Curve**

a. Set the radius to 350

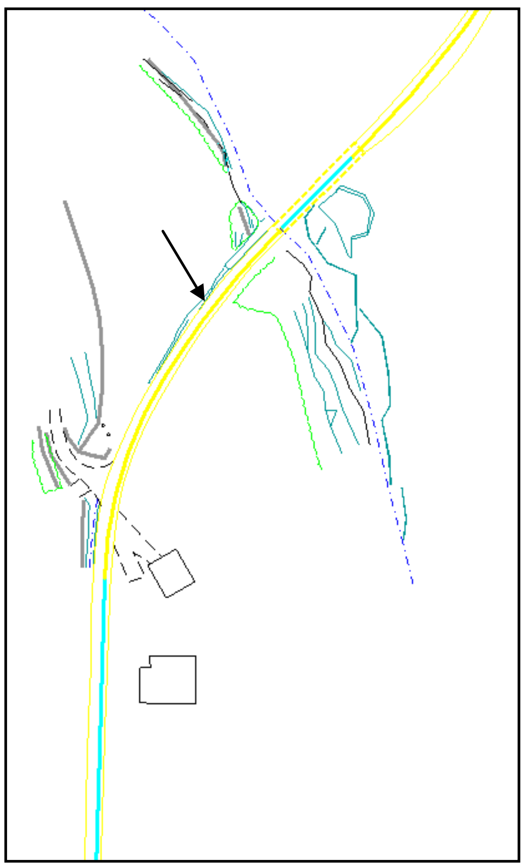


b. Apply

c. Select first tangent and then first curve



Select Tangent



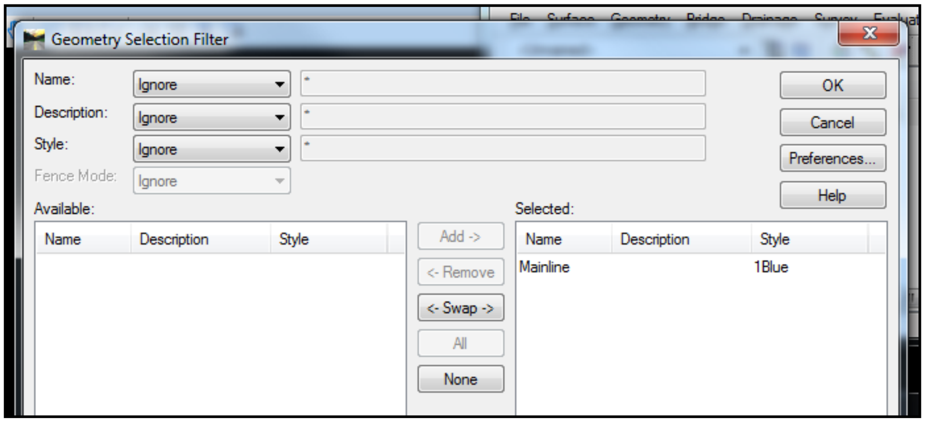
Select Curve

d. Data point to Accept the solution

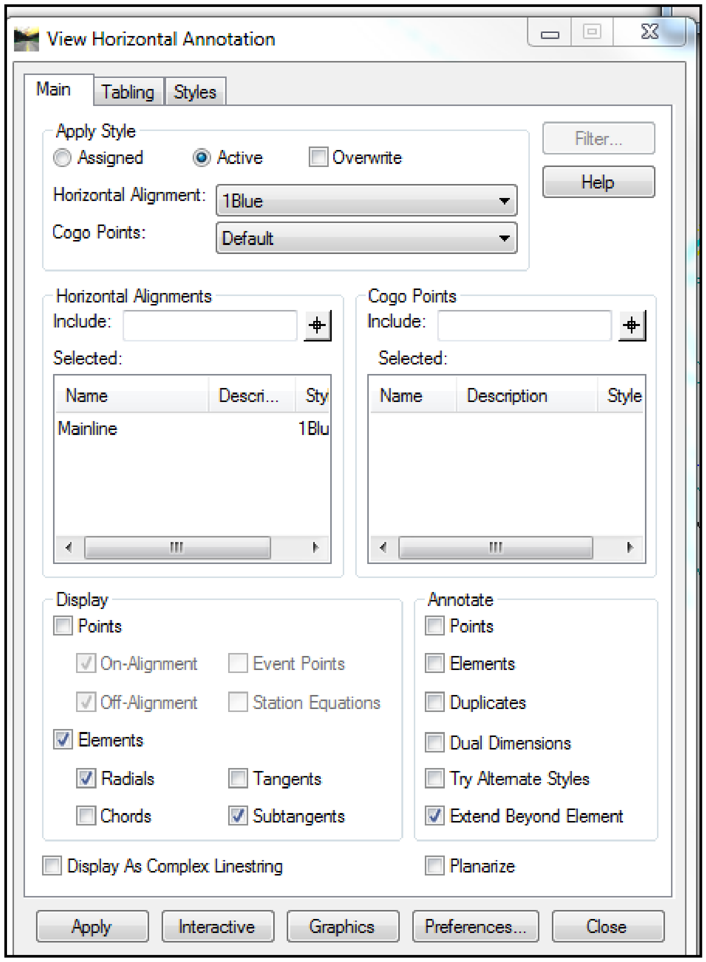
e. Reset and Close to exit the Add Free Horizontal Curve command.

REVIEW ALIGNMENT

1. Select **Geometry > View Geometry > Horizontal Annotation**
   a. Load Preference *Compound Curve*
   b. Include the *Mainline* horizontal alignment
      i. Place cursor in the *Include* field for Horizontal Alignments
      ii. Select **Filter**
      iii. Select *Mainline* under Available and select *Add*

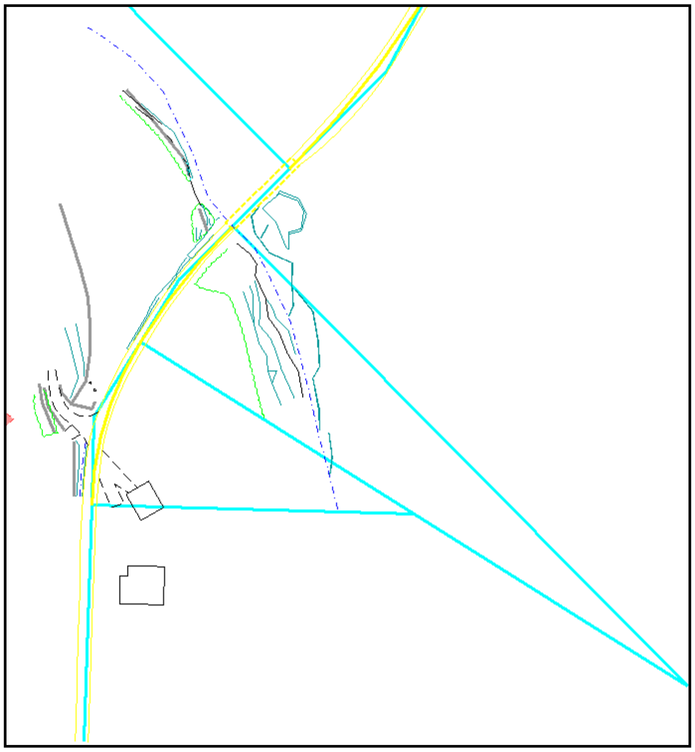


      iv. OK



c. Apply

d. Close



Outcome of Horizontal Annotation

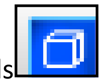
2. Select **Geometry > Review Horizontal**
3. Select **Geometry > Horizontal Element > Check Integrity**

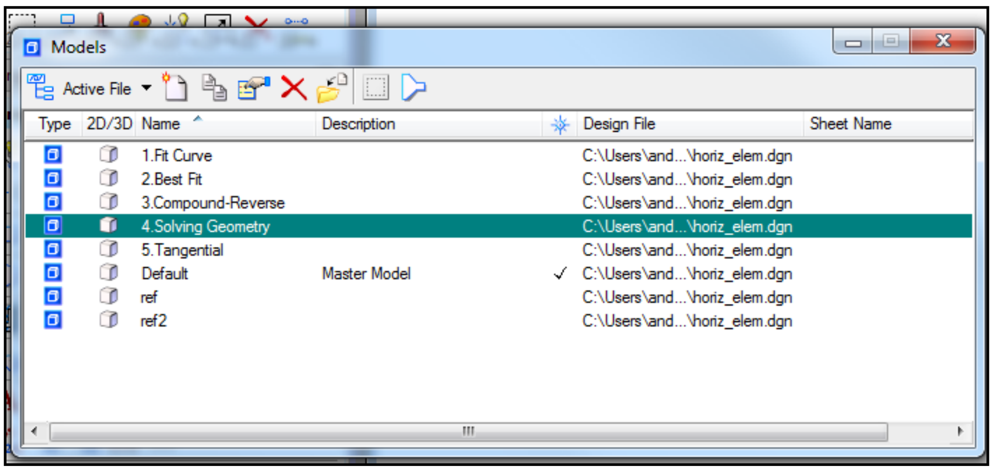
Chapter 4: Solve for an Unknown Geometry

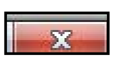
CHAPTER OBJECTIVE:

Similar to the best fit issue in Lesson 2, in this lesson we will be using point data to create an alignment. The given data are three points and a radius for an unknown geometry. Use the Horizontal Element tools to construct the geometry for the data given.

OPEN MODEL

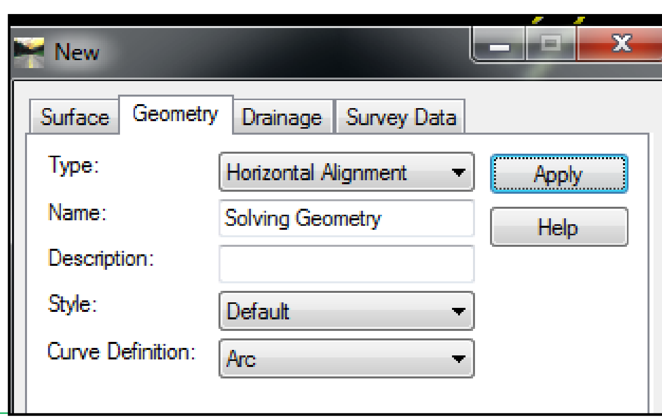
1. Click Models 
2. Double-click on *4.Solving Geometry* to activate that model.



3. Close Models 

CREATE A NEW ALIGNMENT

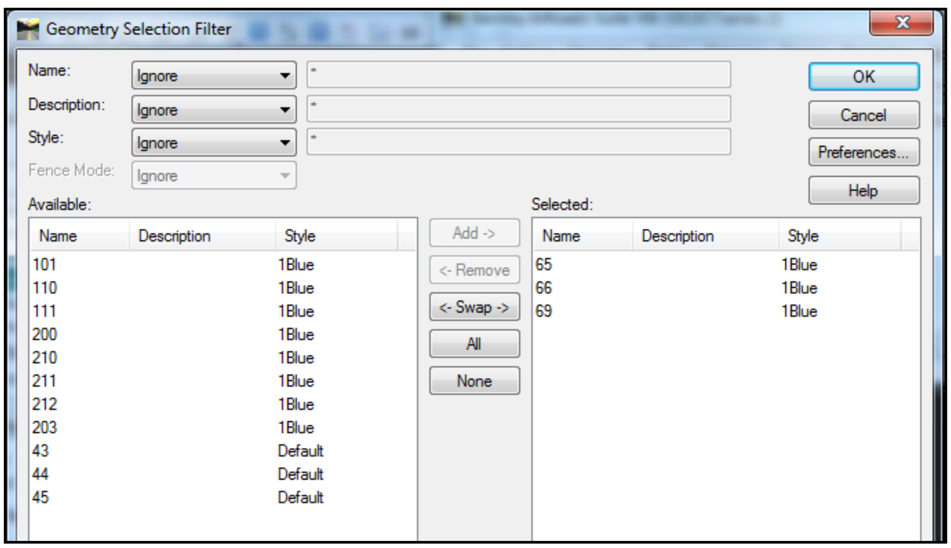
1. Select **File > Power InRoads File > New > Geometry**
   a. Select Type to be *Horizontal Alignment*
   b. Key in *Solving Geometry* for the alignment name
   c. Apply



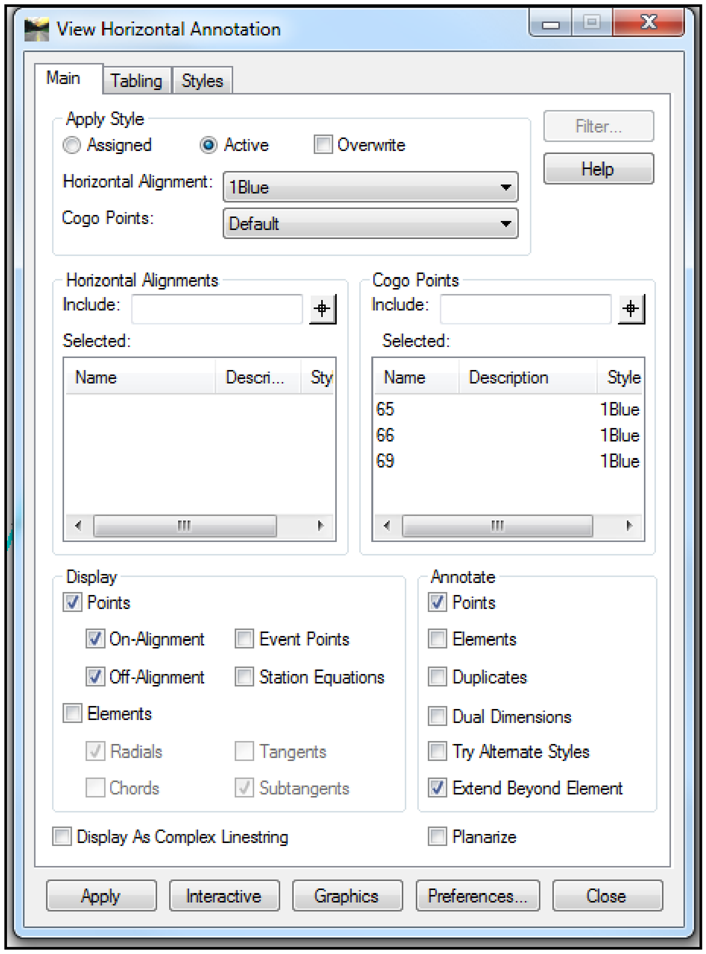
d. Close

VIEW COGO POINTS

1. Select **Geometry > View Geometry > Horizontal Annotation**
   a. Load preference *Solving Geometry*
   b. Remove *Mainline* from the Horizontal Alignments
      i. Place cursor in the *Include* field for Horizontal Alignments
      ii. Select Filter
      iii. Select *Mainline* under Selected
      iv. Remove
   c. Include Cogo points 65, 66, and 69
      i. Place cursor in the *Include* field for Cogo Points
      ii. Select Filter
      iii. Select cogo points *65*, *66*, and *69* under Available and select *Add*

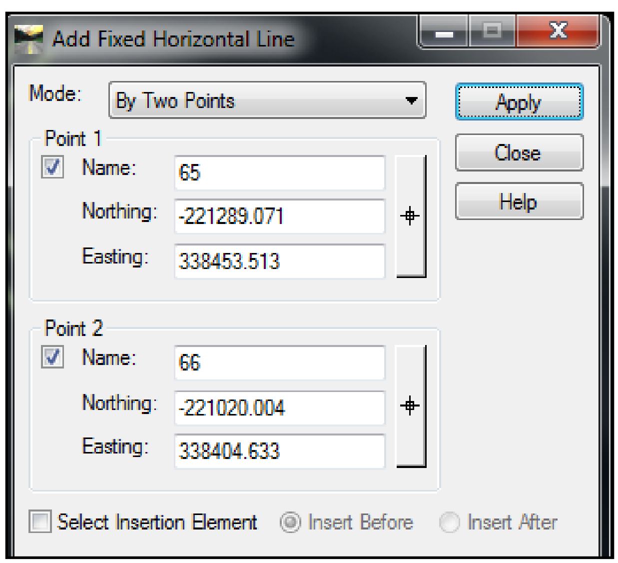


      iv. OK
   d. Apply the Horizontal Annotation command (This will display the cogo points selected in the design file.)



CREATE ALIGNMENT

1. Select **Geometry > Horizontal Element > Add Fixed Line**
   a. The two points used are known (65 and 66)

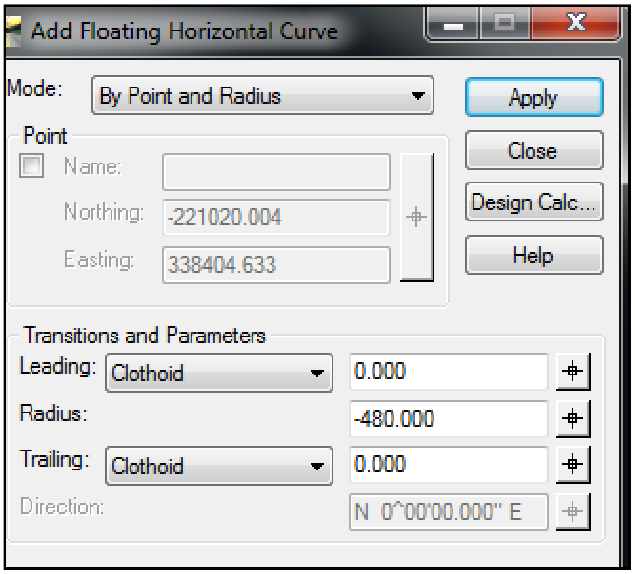


   b. Apply
   c. Data point to Accept the solution

d. Reset and Close to exit the Add Fixed Horizontal Line command

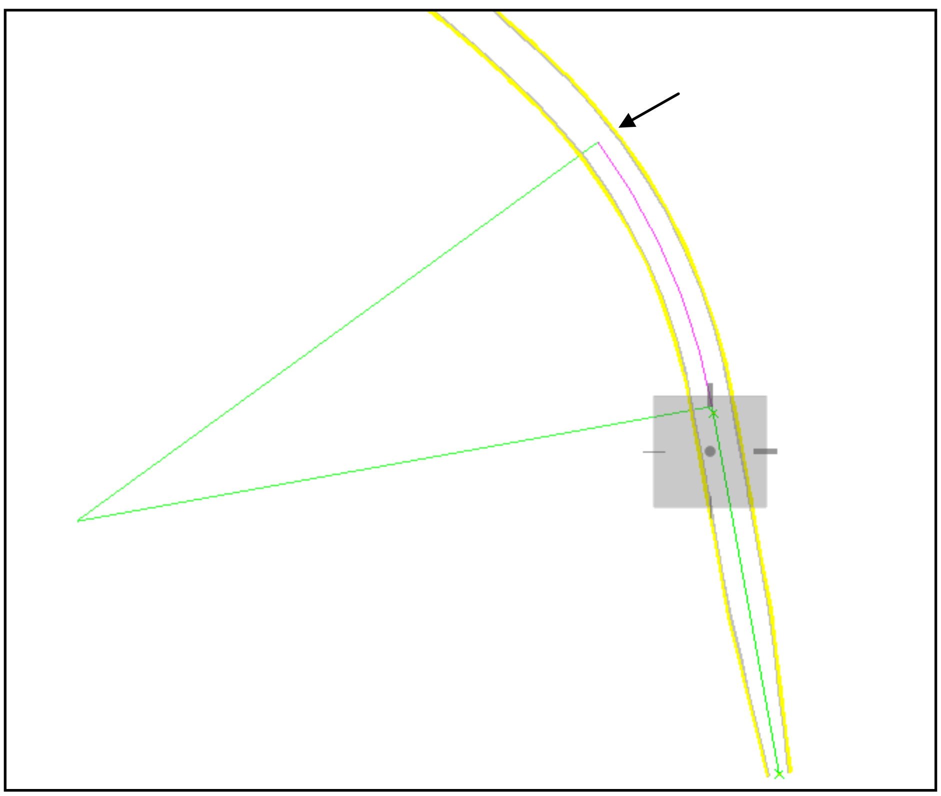
2. Select **Geometry > Horizontal Element > Add Floating Curve**

   a. Key in the known radius



   b. Select the first tangent that was just created

   c. Float the curve out so that it is between the edges of pavements (See Screenshot)

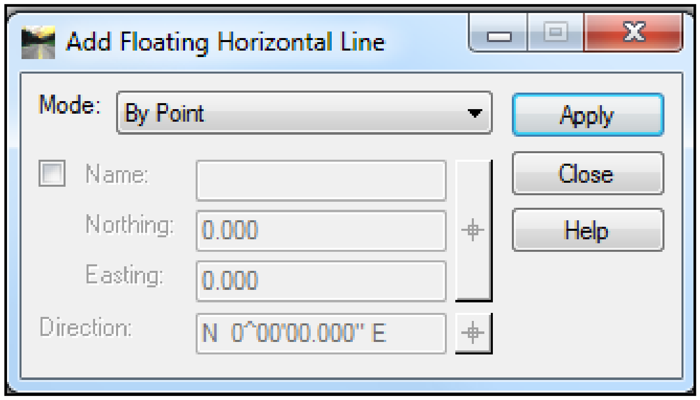


Float Curve between EOPs

   d. Data point to Accept the solution

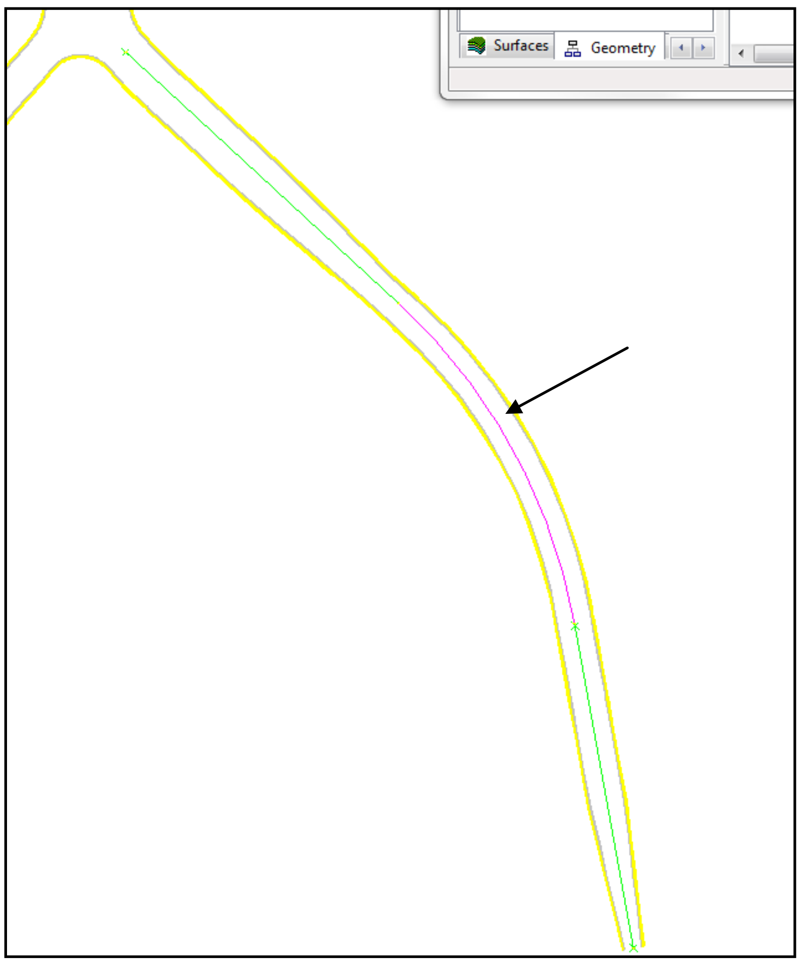
   e. Close

3. Select Geometry > Horizontal Element > Add Floating Line



a. Apply

b. Select the floating curve that was just placed



Select Curve

c. Tentative snap to the cogo point 69

d. Data point to Accept the solution

e. Reset and Close to exit the Add Floating Horizontal Line command

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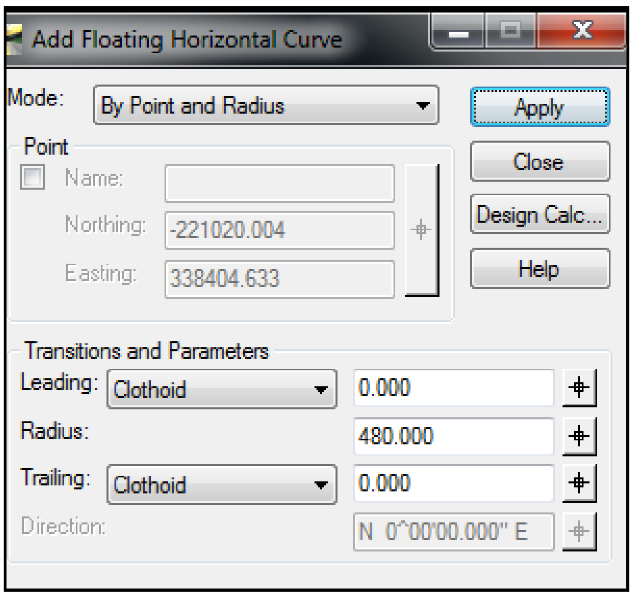
Optional Chapter: Continuation of Solving Geometry

CHAPTER OBJECTIVE:

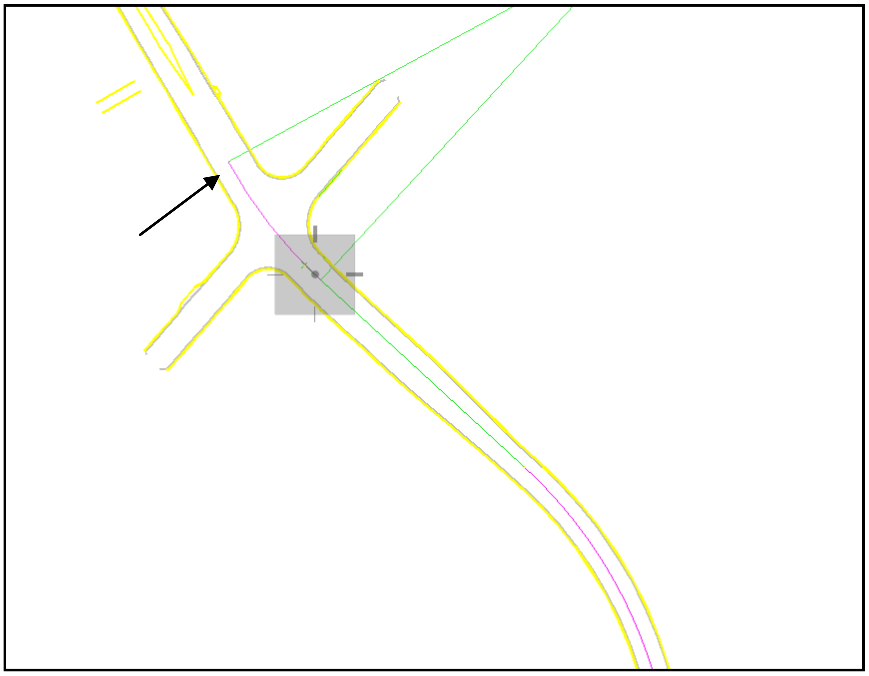
This section is optional if time is allotted. The Solve for an Unknown Geometry (Chapter 4) can be continued with the following workflow. In the following steps, the Floating Line and Curve commands will be used to place a centerline along the remainder of the roadway.

EDIT ALIGNMENT

1. Select **Geometry > Horizontal Element > Add Floating Curve**
   a. Key in a radius of 480



   b. Apply
   c. Select the floating tangent placed in the last section
   d. Float curve out through the intersection

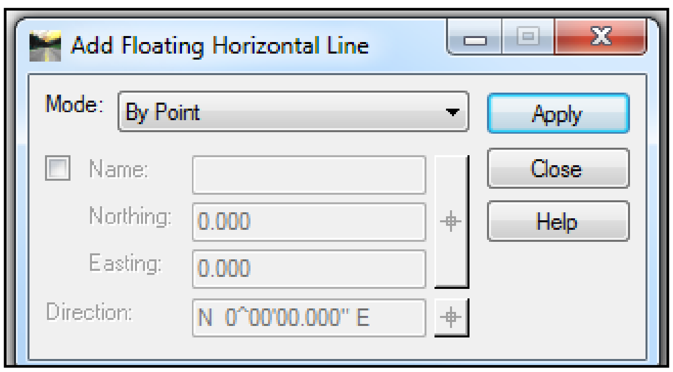


Float Curve

e. Data point to Accept the solution

f. Reset and Close to exit the Add Floating Horizontal Curve command

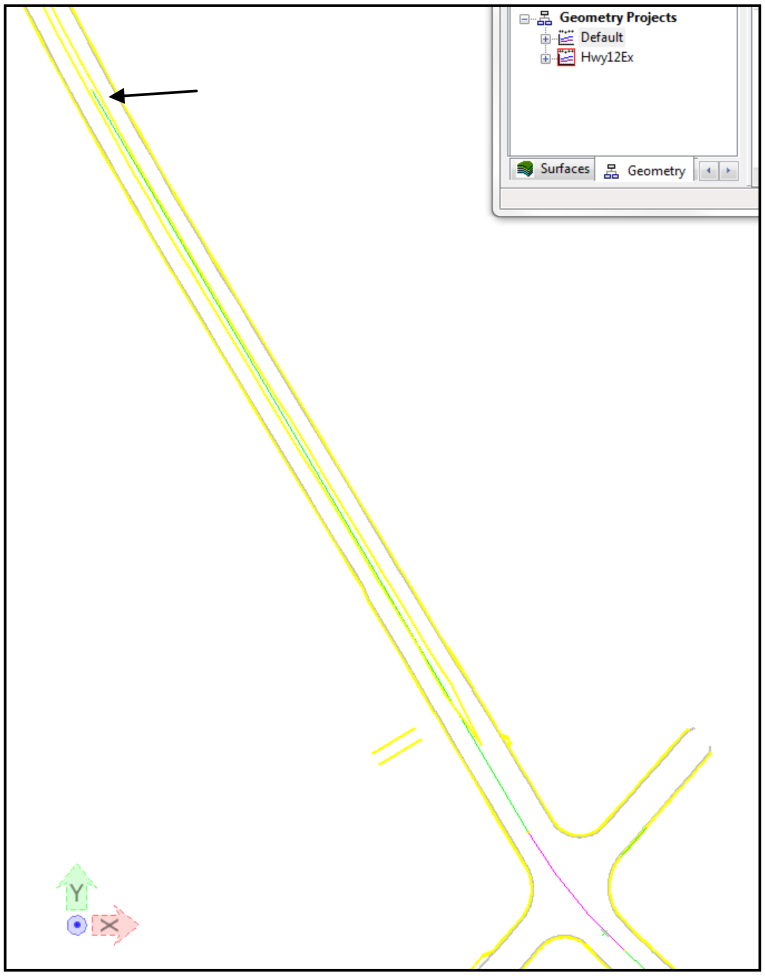
2. Select **Geometry > Horizontal Element > Add Floating Line**



a. Apply

b. Select floating curve just created

c. Float tangent out to the PC of the next curve



Float Tangent

d. Data point to Accept the solution

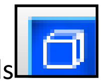
e. Reset and Close to exit the Add Floating Horizontal Line command

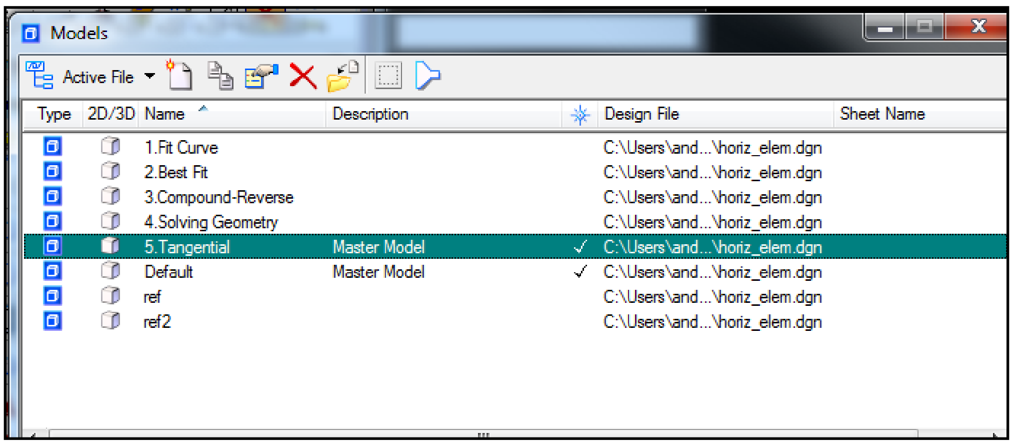
Chapter 5: Create a Continuous Tangential Alignment

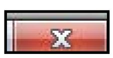
CHAPTER OBJECTIVE:

Displayed in the CAD drawing are elements representing a driveway component. However, these elements are non-tangential. The goal is to recreate the curve while maintaining the tangency of the linear elements.

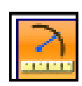
OPEN MODEL

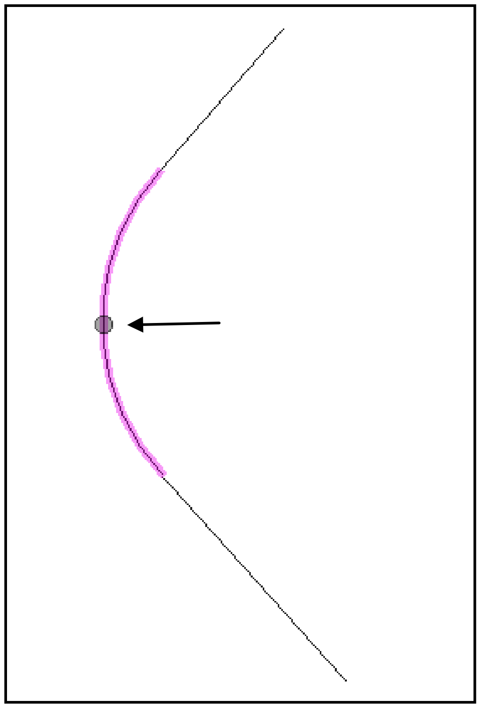
1. Click Models 
2. Double-click on *5.Tangential* to activate that model



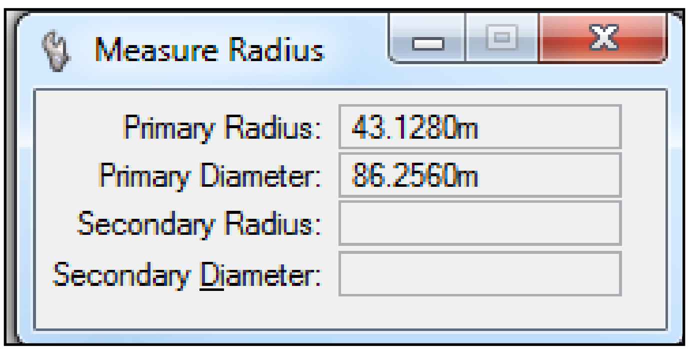
3. Close Models 

MEASURE RADIUS

1. Select the *Measure Radius* tool in the *Drawing* tools. 
2. Select the curve in plan view

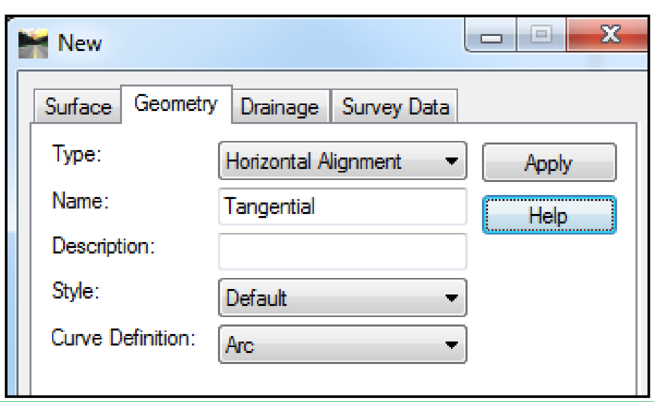


3. Read and record the radius given in the Measure Radius dialog



Create a New Alignment

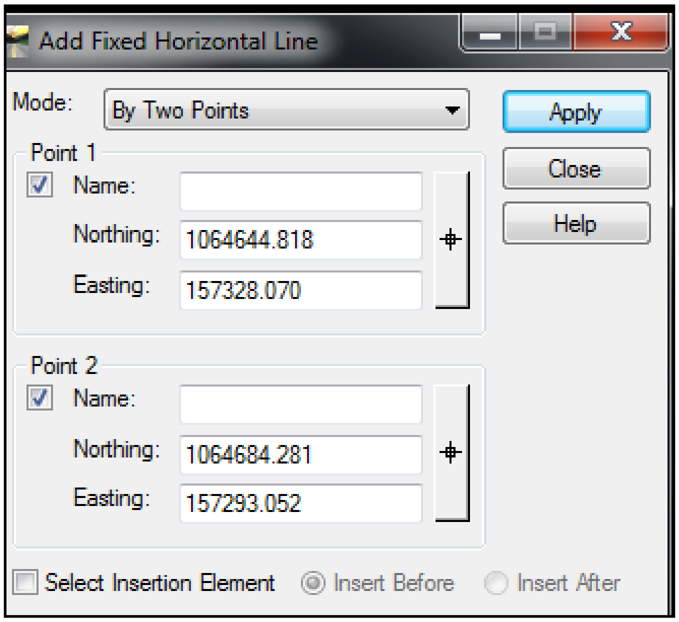
1. Select **File > Power InRoads File > New > Geometry**
   a. Select Type to be *Horizontal Alignment*
   b. Key in *Tangential* for the alignment name
   c. Apply

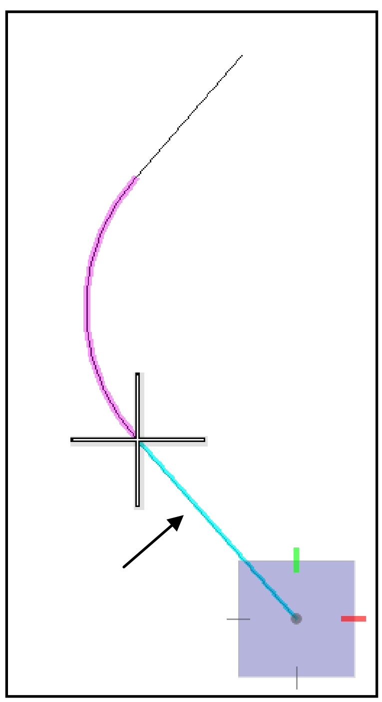


d. Close

Edit Alignment

1. Select **Geometry > Horizontal Element > Add Fixed Line**
   a. Select Point 1 to be at the bottom of the first tangent line
      i. Use the target button to tentative snap to Point 1
   b. Select Point 2 to be at the beginning of the arc
      i. Use the target button to tentative snap to Point 2



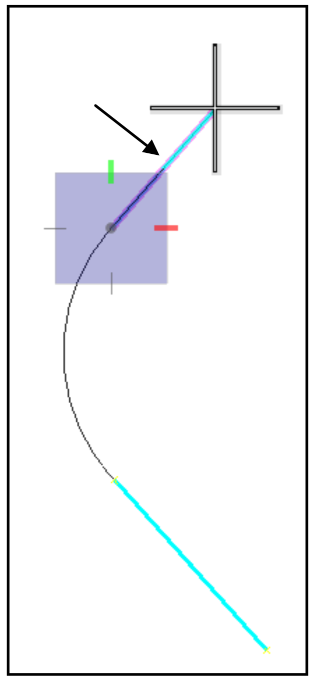


   c. Apply

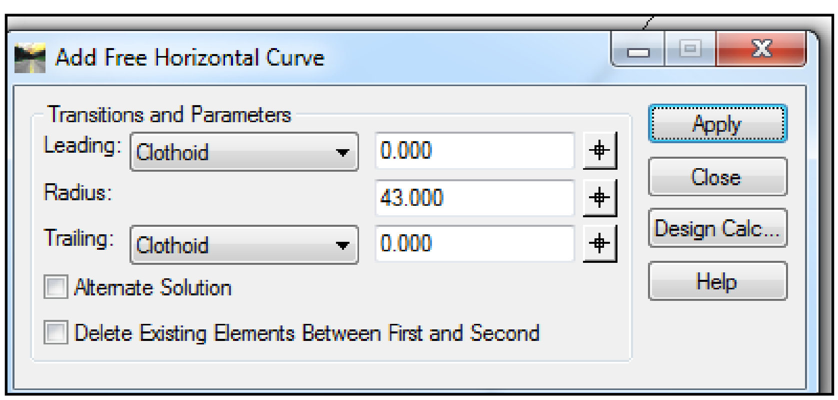
d. Data point to Accept the solution

e. Reset to return to the Add Fixed Horizontal Line command

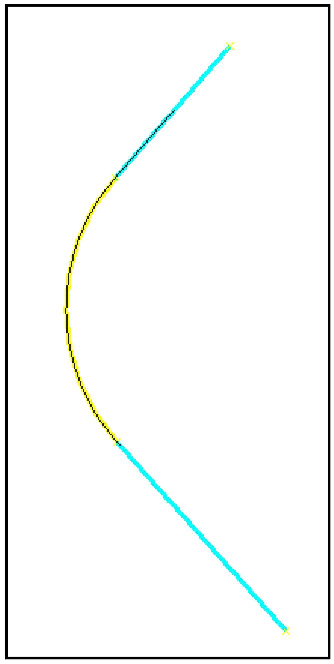
2. While working in the Add Fixed Line command, define the second tangent
   a. Select Point 1 to be at the end of the arc
      i. Use the target button to Tentative snap to Point 1
   b. Select Point 2 to be at the end of the second tangent element
      i. Use the target button to Tentative snap to Point 2



   c. Apply
   d. Data point to Accept the solution
   e. Reset and Close to exit the Add Fixed Horizontal Line command
3. Select **Geometry > Horizontal Element > Add Free Curve**
   a. Key in a radius of 43
   b. Apply



   c. Select the first tangent
   d. Select the second tangent



Curve placed between tangents

e. Data point to Accept the solution

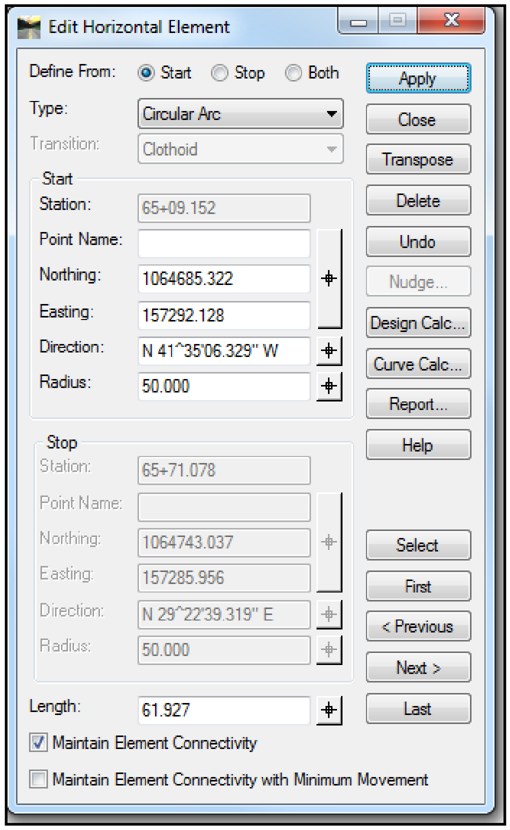
f. Reset and Close to exit the Add Free Horizontal Curve command

Review Alignment

1. Select **Geometry > Horizontal Element > Check Integrity**

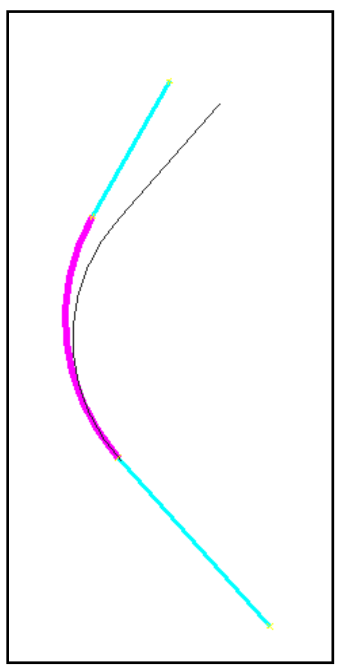
Edit Alignment

1. Adjust radius of curve to "flatten" it
    a. Select **Geometry > Horizontal Element > Edit Element**
        i. Select *Next* to step through the alignment to the curve element
        ii. Key in a radius of 50
        iii. Select *Maintain Element Connectivity*



iv. Apply

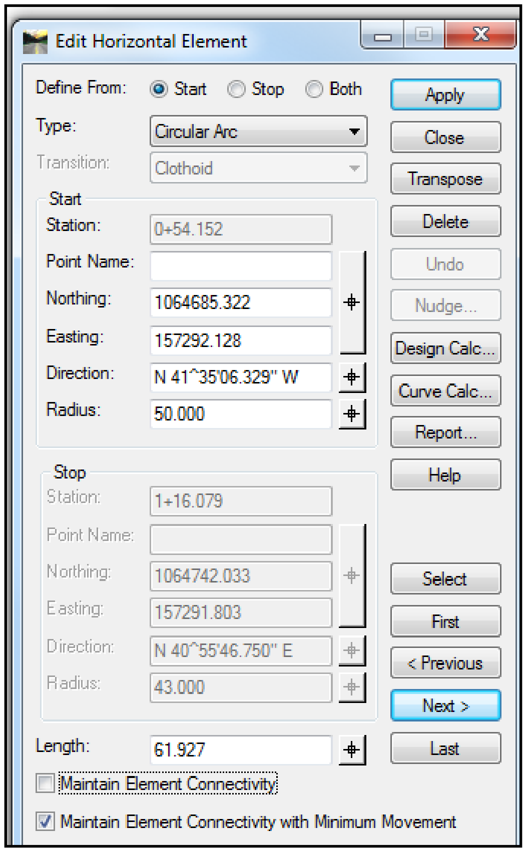
Note	Notice the edits made to the alignment



Connectivity shown here

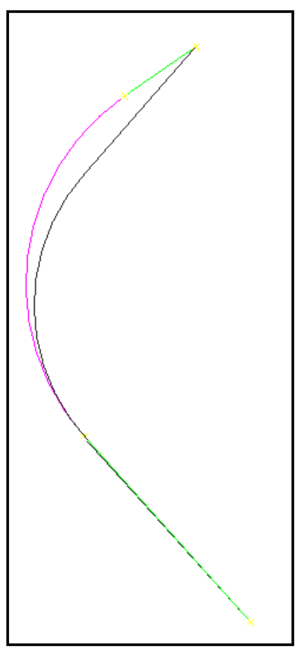
v. Select *Undo*

vi. Select *Maintain Element Connectivity with Minimum Movement*



vii. Select Apply

Note Notice the edits made to the alignment



Minimum movement shown here