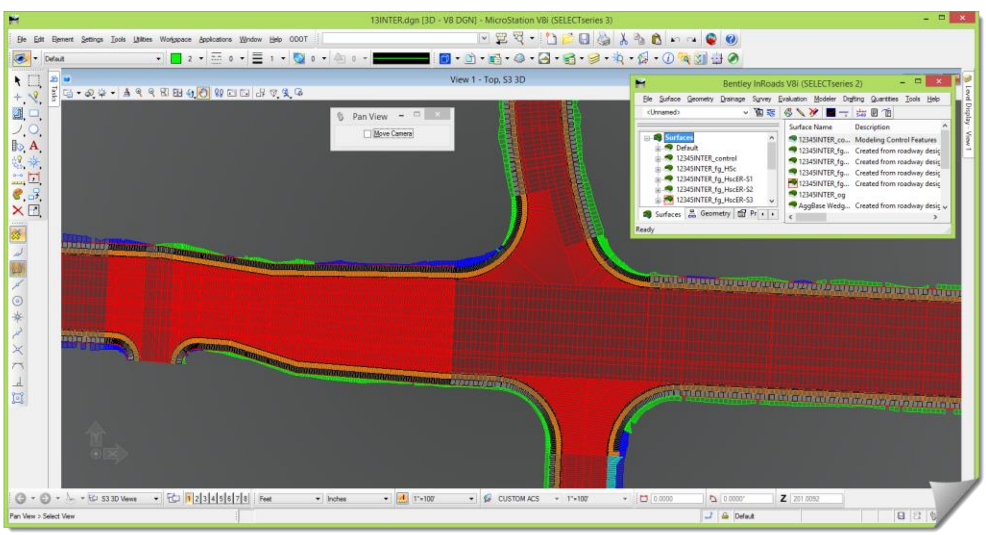
Module 13

INTERSECTION MODELING

Using InRoads

Introduction

The 2012 ODOT Highway Design Manual, Chapter 16, 3D Roadway Design, section 16.3.4.6, INTERSECTIONS – states, “*There is no ‘easy way’ to model an intersection. Designers unfamiliar with this process should review the available EAST documentation and contact EAST members and other experienced designers for assistance.*” Due to the potential complexities that an intersection can have, this is a true statement.



There are, however, InRoads techniques that can be applied during intersection modeling that, when understood, can be used in many different intersection applications. For instance, modeling in separate corridors and creating a common surface from the **ROADWAY DESIGNER** is an effective technique. This, combined with assigning strategic **POINT CONTROLS** can produce modeling that is more representative of the completed project. With these basic tools, you can take your design modeling results further.

Purpose of this Module

This module will show modeling fundamentals that can be applied in any intersection, including:

- Modeling several different intersection types including skewed intersections
- Modeling an intersection where not all of the approaches are being completely rebuilt (inlay only) and match OG at the end of the curb returns
- Combining surfaces and illustrating the impacts on component integrity

Objectives of this Module

At the end of this module, you will be able to use InRoads to model intersections with various complexities and integrate secondary roads into the primary roadway model.

Definition of Audience for future Modules

Please note that this module assumes that you have a certain level of competency with the software tools and will be asking you to execute some commands with very little instruction. This module was designed with a certain technical audience in mind, so ensure that you have the proper prerequisites.

Skill Level / Prerequisites:

The prerequisites for this module are the following:

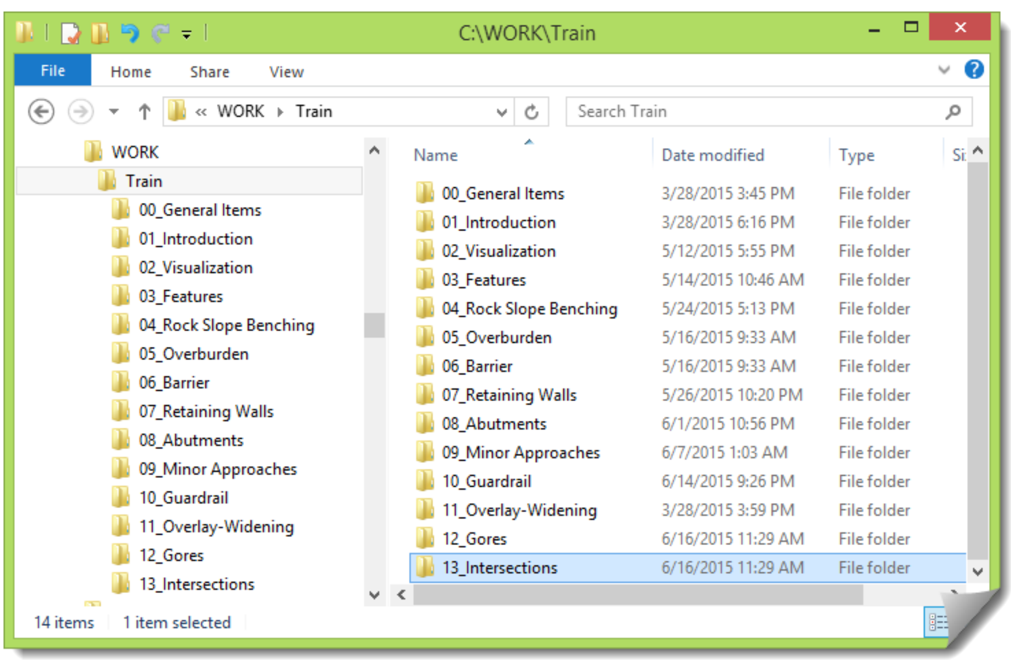
- MicroStation Basics
- InRoads Level 1
- InRoads Level 2
- Module 1 – Introduction to the Training Modules
- Module 2 – Visualization
- Module 8 – Abutments
- Module 9 – Minor Approaches

Module Files and Folders

Training Folders

You will be working on your own hard drive during this training. The module instructions will expect the training files and folders to be set up as shown here in order to align with the module directions.

You should have the **`13_Intersections`** training folder and files on your local drive. The module folder and related files should be placed under the ***C:\WORK\Train*** folder, and look like this:



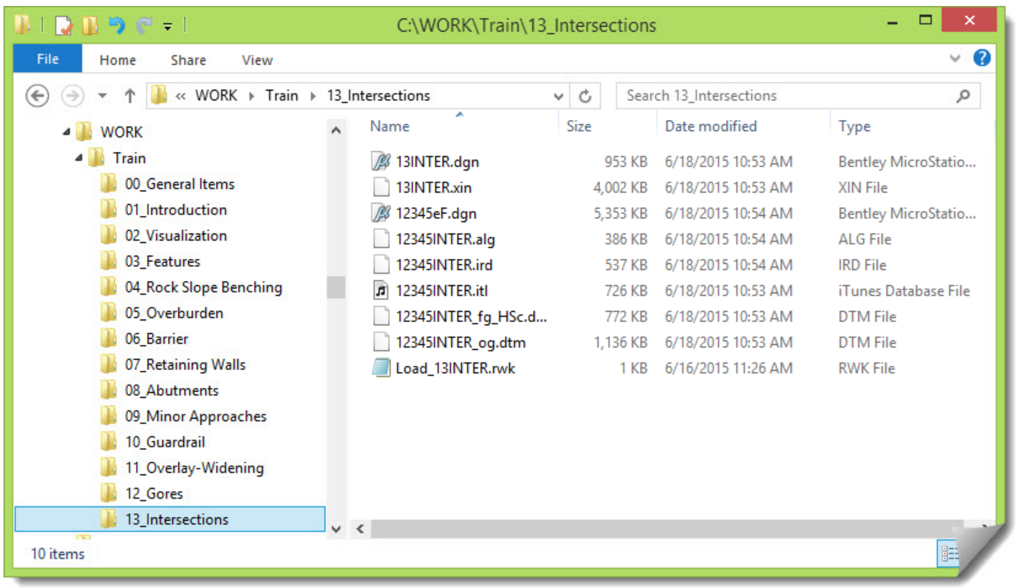
Training Files

The module folder contains all the files that will be used in these exercises including:

- **13INTER.dgn**, the initial MicroStation file used at the start of the exercises
- **13INTER.xin**, the InRoads configuration file for this work

There is an **RWK** file included in the module folder to assist in opening the InRoads files.

In this module folder, you should have these files:

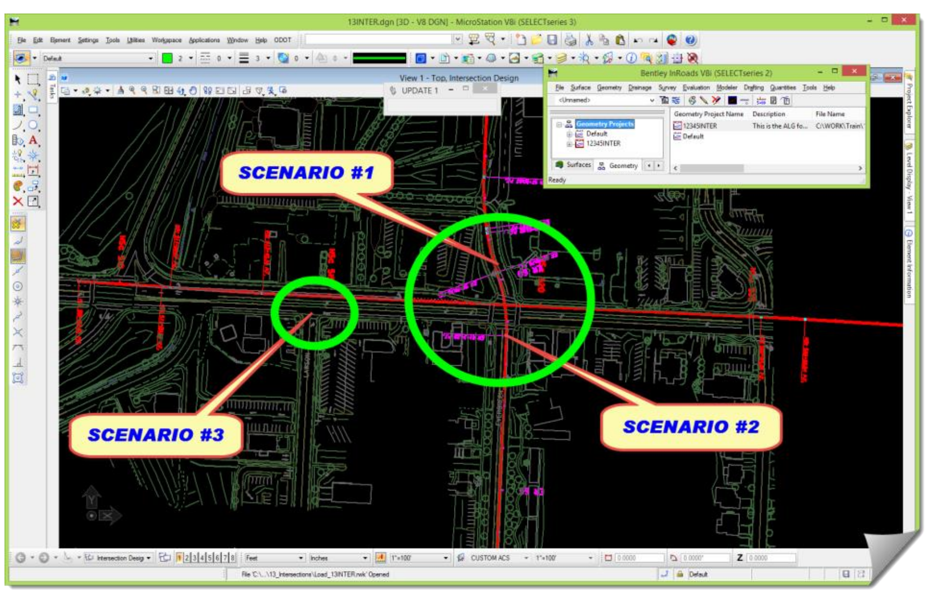


Technical Content of Training:

Project Orientation

REVIEW WORK AREA

The focus of the intersection modeling work is shown here:



PREPARE MICROSTATION / INROADS DATA & FILES

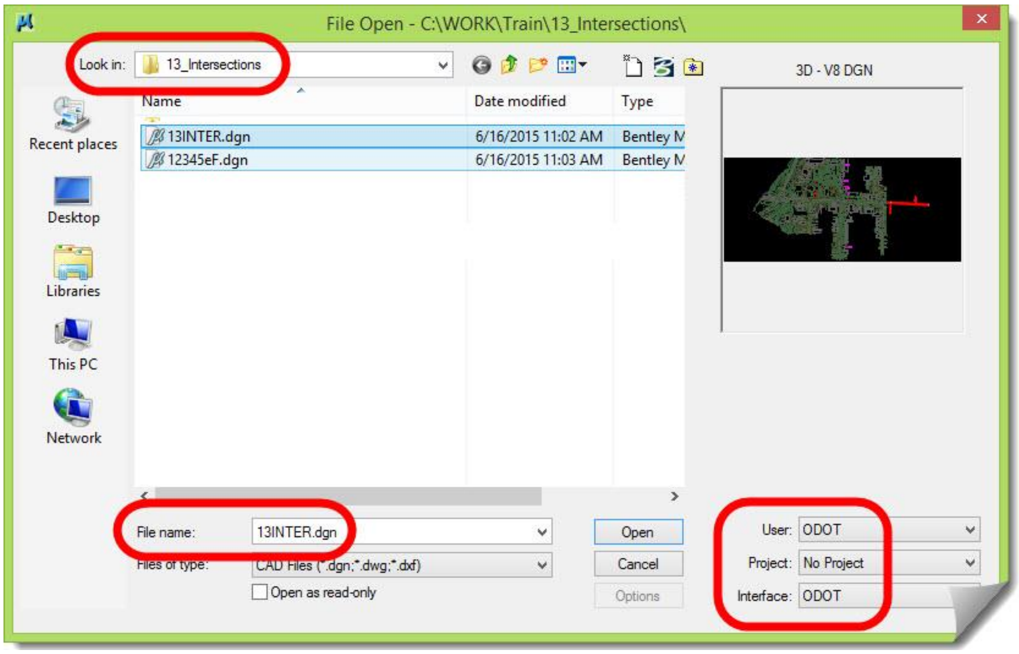
This section will get you into the DGN, load the module-specific XIN and other data files.

1) Launch InRoads

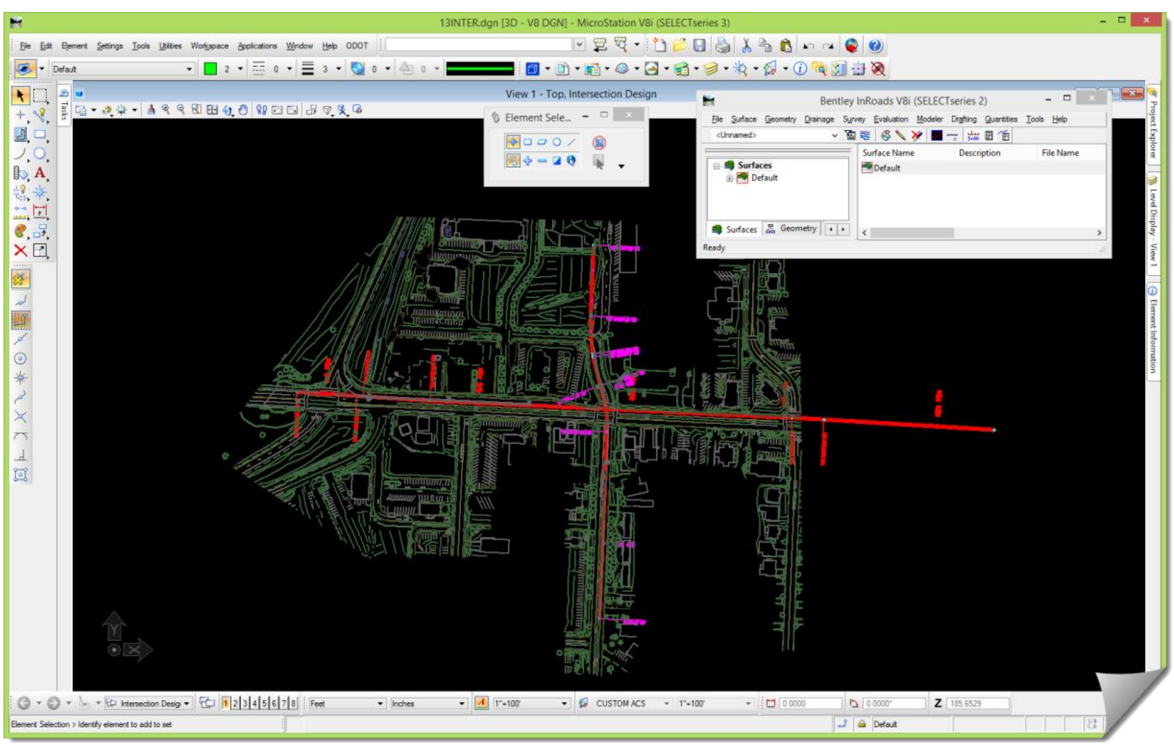
Use whatever mechanism you are familiar with to get the software started.

2) When the **MicroStation Manager** opens, set the **User** and **Interface** to **ODOT**.

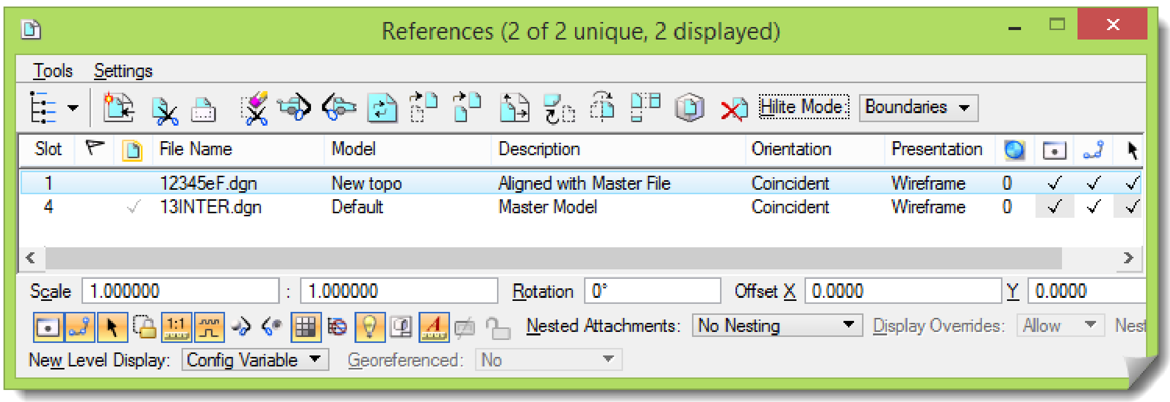
3) Browse ***C:\WORK\Train\13_Intersections***, select **13INTER.dgn**, and [**Open**].



4) When the drawing opens, you'll see that it is has some content.



5) Open Windows **File Explorer** and browse to the **13_Intersections** folder.
6) Drag & drop **Load_13INTER.rwk** into the InRoads interface to open the InRoads files.
7) Verify inside InRoads that the following files have been opened:
    - **13INTER.xin**
    - **12345INTER_og.dtm**
    - **12345INTER_fg_HSc.dtm**
    - **12345INTER.alg**
    - **12345INTER.itl**
    - **12345INTER.ird**
8) Feel free to review the project data just opened.
9) Review the MicroStation models and reference files that are attached to this drawing so that you are oriented to the DGN file that is open.



10) Move forward into the study portion of this module. Feel free to interact with the software as needed during your study in order to solidify any of the items under discussion.

Theory - Study

In this module, the project design geometry, templates and corridor are partially completed and will establish the starting point. From this starting point, the current corridor in the **Roadway Designer** will be modified based on the developing details of the intersections to be modeled. New geometry will also be constructed as the basis for new corridors as well as new **Point Controls**. Throughout this module, template creation and template modification will be done as needed.

PROCESS OVERVIEW

Important Module Note: Reference to the specifically named alignments below is not always done in this module. Instead, they are referred to as the *Primary* and *Secondary* roads or corridors. This is done deliberately to get you thinking in terms of the *primary* (or main) and *secondary* corridors, and for you to begin to integrate this identification to your project roadways.

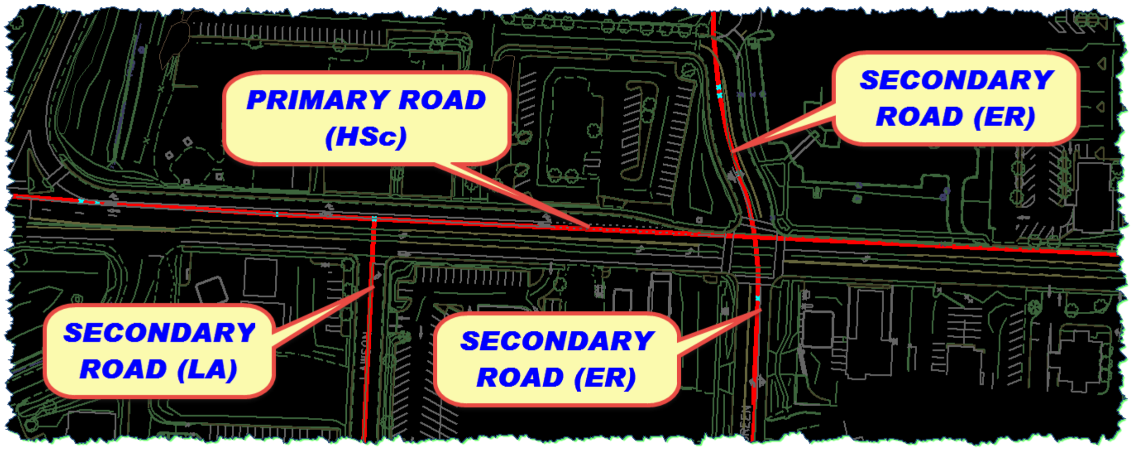
The techniques shown in this module have a pattern of performing certain corridor modification to the *primary* or main road, and then modification to the *secondary* or intersecting road. Thinking in these general terms is intended to conceptualize the techniques presented here.

In the case of the work done in this particular module the *Primary* roadway will be **HSc**, and the *Secondary* roads are **ER** and **LA**.

Things to Consider

Primary & Secondary Roads

When constructing intersection models there are certain traits, as well as techniques, that are associated with the primary road, and others that are typically associated with the secondary road.



Primary Road:

- Main horizontal alignment that tends to drive the horizontal position and potential orientation of other alignments
- Usually contains the 'typical' modeling section and cross-slope that carries through from the start of the alignment until the end of the alignment
- Often modeled first, and whose grades and resulting features have a strong influence on neighboring grades and features of alignments that intersect or come in contact with it
- Usually acts as a basis or foundational anchor that other intersecting roads are integrated into
- The corridor for this model, more often than not, excludes the modeling of any significant intersection returns
- Generally <u>does</u> include the integration of driveways and minor approaches into its modeling
- When combining corridors with **Clipping Options**, this is typically the model that others are trimmed against, and acts as the 'clipping' corridor

Secondary Road:

- Usually an alignment that is laid out after the primary road, and that intersects the primary road
- Vertically, this roadway alignment is designed to tie into the design of the primary road
- The corridor of a secondary road is developed after the design of the primary road
- The corridor for this model , more often than not, includes the modeling of any significant intersection returns
- When combining corridors, typically this model is trimmed against the primary design model and when applicable, is the 'clipped' corridor

General Intersection Modeling Workflow

As an overall orientation, intersection modeling can take this general outline:

a. Layout the Horizontal and Vertical alignment for the primary roadway
b. Construct the required templates for that road
c. Set up the model for the primary roadway as ordinarily done and with as much detail as you have available. This includes any **END CONDITION EXCEPTIONS**, required transition editing, **POINT CONTROLS**, **PARAMETRIC CONSTRAINTS** and **SUPERELEVATION**. The only exclusion for the design details would be those in the area of the intersections.
d. Review the primary road design model in the **ROADWAY DESIGNER**
e. Create and review the primary road design surface
f. Layout the horizontal alignment for the secondary road
g. Create a profile for the secondary road along its centerline
h. View the original ground as well as the primary road design
i. Layout the secondary road vertical alignment making sure that it precisely ties into the primary road design
j. Plan out how the secondary road corridors will be modeled since each side of the secondary road (if it passes through the primary road) will be modeled in separate corridors
k. Create the initial templates for the secondary road in the Create Template tool
l. Create the initial corridor for the secondary road (including Superelevation if applicable)
m. Use the geometry **MULTICENTER CURVE** tool to construct both the horizontal and vertical alignments for the intersection returns
n. Create a profile along each return horizontal alignment and view the vertical alignment, checking for positive drainage and ADA-compliant cross slope and edit as needed
o. Based on the new returns, define the primary road stationing for the start and end of the new / modified template that will run through the intersection
p. Create new templates to add along the primary road to remove any ECs, curb and sidewalk. The ECs, curbing and sidewalk should not be running through the intersection with the secondary road. This is done to eliminate partially deleting breaklines later.
q. Add additional template drops in the **ROADWAY DESIGNER** to apply the new templates from the previous step. The primary road templates and drops are modified to create a clean model through the intersection starting at the PC of the first return and ending at the PT of the second return further down station.
r. Revise the corridor for the secondary road with templates located to ensure a clean modeling connection with the primary road (this will be discussed in more detail later)
s. Define all of the secondary road details such as **PARAMETRIC CONSTRAINTS** and any required **POINT CONTROLS**
t. Add **Horizontal** and **Vertical POINT CONTROLS** to the secondary road corridor for the returns that tie into the primary road
u. Create a design surface of the intersection that contains all of the corridors for that area
v. Review the final surface by displaying **FEATURES** / **TRIANGLES** / **CONTOURS** or any 3D views
w. Review the final model for any drainage issues
x. Save that design surface

Techniques and Tools

At this stage of your current level of InRoads expertise, intersection modeling becomes mainly about techniques and workflows, as the vast majority of tools should be more or less understood.

Specific Tools:

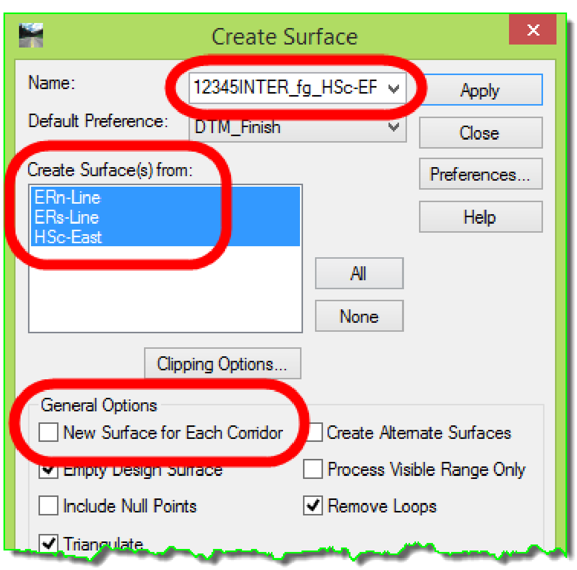
The main tools that are used to develop an intersection model are:

- **Multicenter Curve** tool – to construct the horizontal and vertical alignments for the intersection returns based on the horizontal and vertical alignments of both the primary and secondary roads. These will eventually be used in the **Roadway Designer** as **Point Controls** on either the secondary road in the case of an intersection, or the primary road in the case of matching a minor approach, or possibly as a separate corridor path.
- **Point Controls** – this functionality is critical to most any roadway model where a portion of the template section has to retain its own path independent of the centerline. This functionality is also the basic nature of **Superelevation** in the **Roadway Designer**.

  Intersection modeling requires a strong foundation of **Point Controls**, and should embrace all of the different types of controls – **Alignment**, **Feature**, **Style** and **Corridor**.

  In addition, the **Secondary Alignment** toggle plays a key role in this type of modeling.
- **Target Aliasing** and **Corridor Clipping** – this capability of the **Roadway Designer** can be brought into play during intersection modeling when there is a need to trim one corridor against the modeling of another corridor. The aliasing is set up in the specific **Corridor**, whereas the clipping is defined when creating the final design surface.

  Whether this functionality is needed or not is dependent upon how the corridors are created. If the template drops are strategic enough with a strong use of **Point Controls**, **Corridor Clipping** can be eliminated. If the end stationing of the secondary road corridor pushed its termination into the primary roadway, like in a gore area, then corridor clipping can be employed to trim back the secondary road as it meets the primary road.
- **Create Surface** – the variation that may be unlike what you've done with InRoads in the past will be the creation of a single design surface from the **Roadway Designer**. This entails selecting multiple corridors and <u>not</u> creating a **New Surface for Each Corridor**.



Practical Application - Hands On Lab Exercises

UNDERSTANDING THE DETAILS

The next section will provide a chance to review the project data, focusing on the geometry, templates and **ROADWAY DESIGNER** corridor that have already been done to start this module.

The end goal for this section is that you understand how this sample project is set up, why it is set up as it is, and be able to incorporate the required changes in the area of the intersections.

Review any relevant project data

At this point, you should be in the **13INTER.dgn** file and have loaded the InRoads RWK data.

1) Select any graphics you may have displayed and delete them from the MicroStation file.

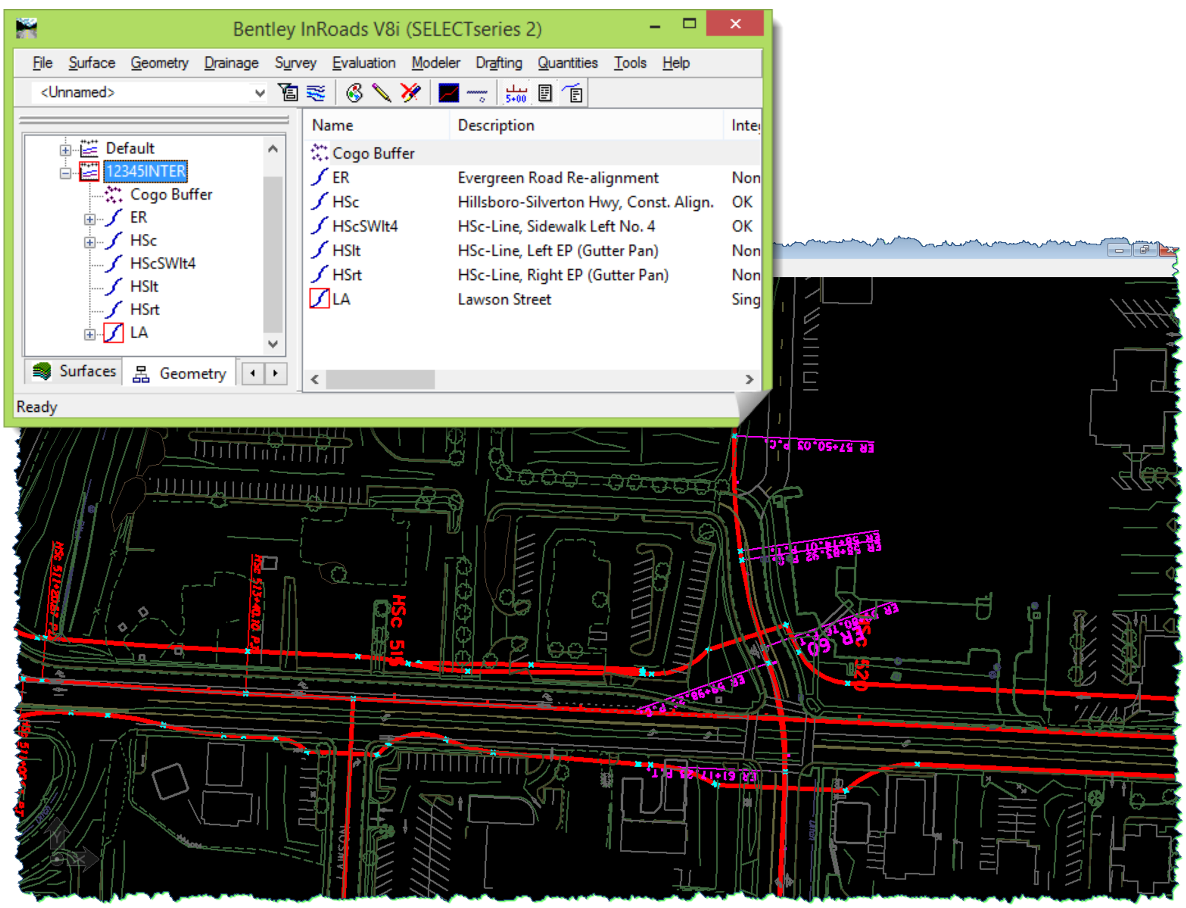
Start with a clean MicroStation file, free of graphics, for future display work that you may do.

Review Project Geometry

In this section, you will review at your own pace, the project geometry that has been set up for this module.

1) Review the horizontal and vertical alignments in the geometry in any way you need to in order to understand their locations and stationing, both horizontally and vertically.

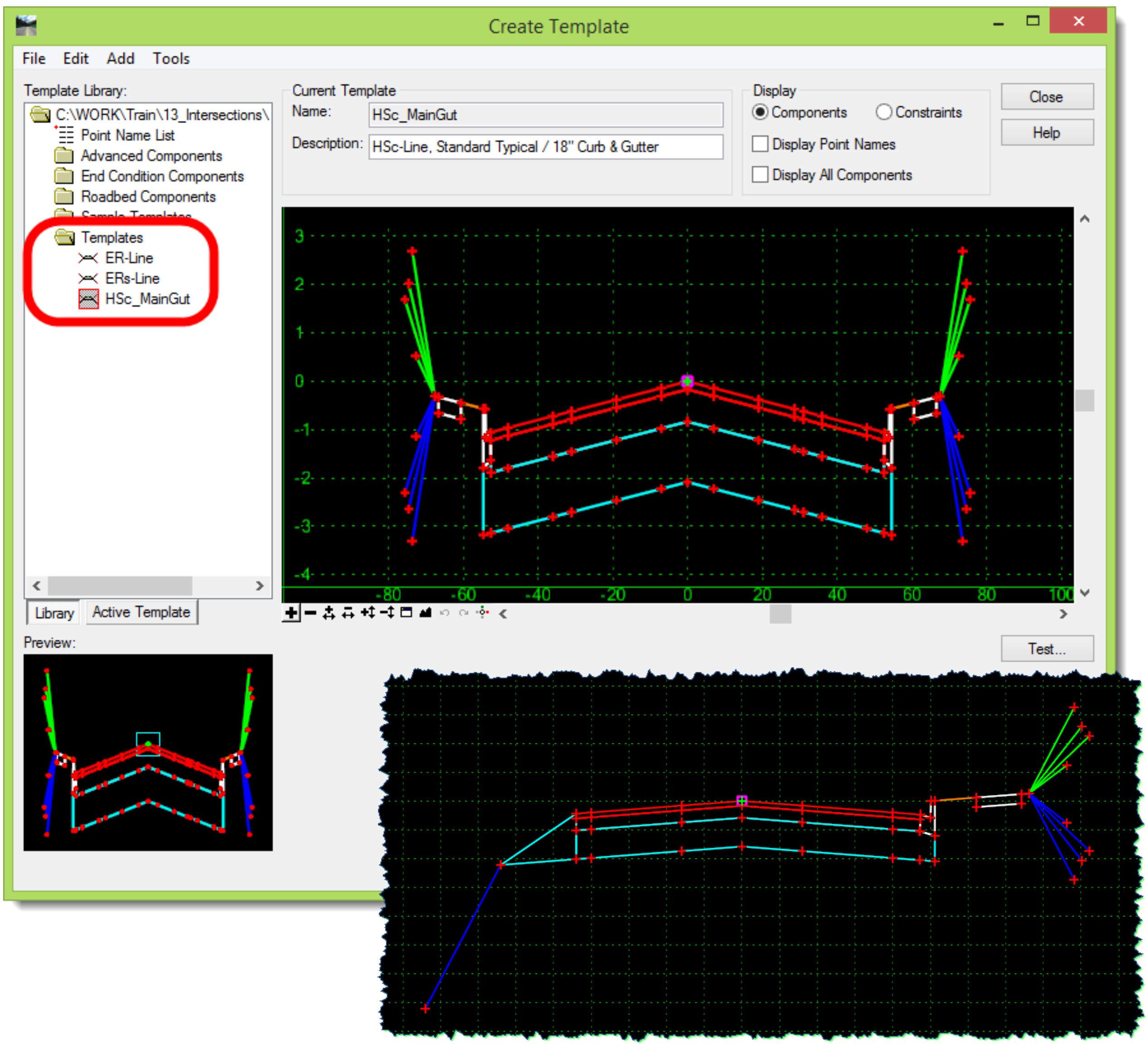
The main alignments are **HSc** for the primary roadway, **ER** for the secondary road and **LA** for the minor approach along **HSc**. These are the only horizontal alignments that have associated vertical alignments. The other **HS** alignments are used as **POINT CONTROLS** along the **HSc** alignment.



Review Project Templates

Now you will review, at your own pace, the project-specific templates for this module.

1) Go to **Create Template** and browse to the **Templates** folder.
2) Review the three roadway templates used and set up for this module.
   - **`HSc_MainGut`** – this template is used along the entire stretch of the primary road running along alignment **`HSc`**
   - **`ER-Line`** – this template will be used to model the northerly portion and part of the southerly portion of the intersection built in this module, and will be run along the **`ER`** alignment representing the secondary road
   - **`ERs-Line`** – this template will be used to model the southerly portion of the **`HSc`** – **`ER`** intersection and will also run along the **`ER`** alignment

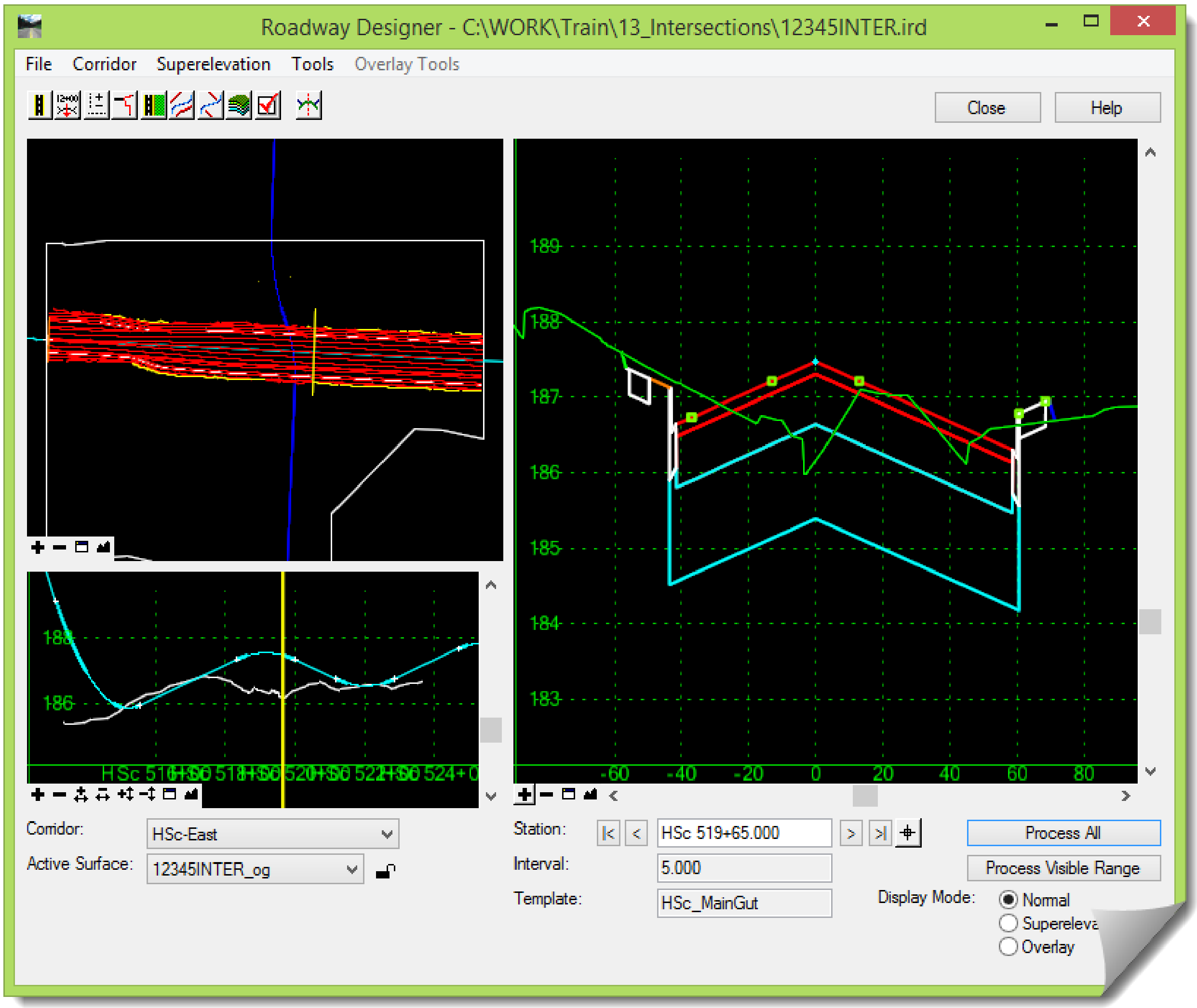


3) [**Close**] the **Create Template** tool when your review is complete.

Review Project Corridor

Let's look at the **Roadway Designer** corridor for the primary road.

1) Open the **Roadway Designer,** verify that the **Corridor** is set to **`HSc-East`** and the **Active Surface** is set to the **OG**.
2) Do whatever you feel you need to do in order to review and familiarize yourself with how this corridor is constructed.



3) [**Close**] the **Roadway Designer** for now.

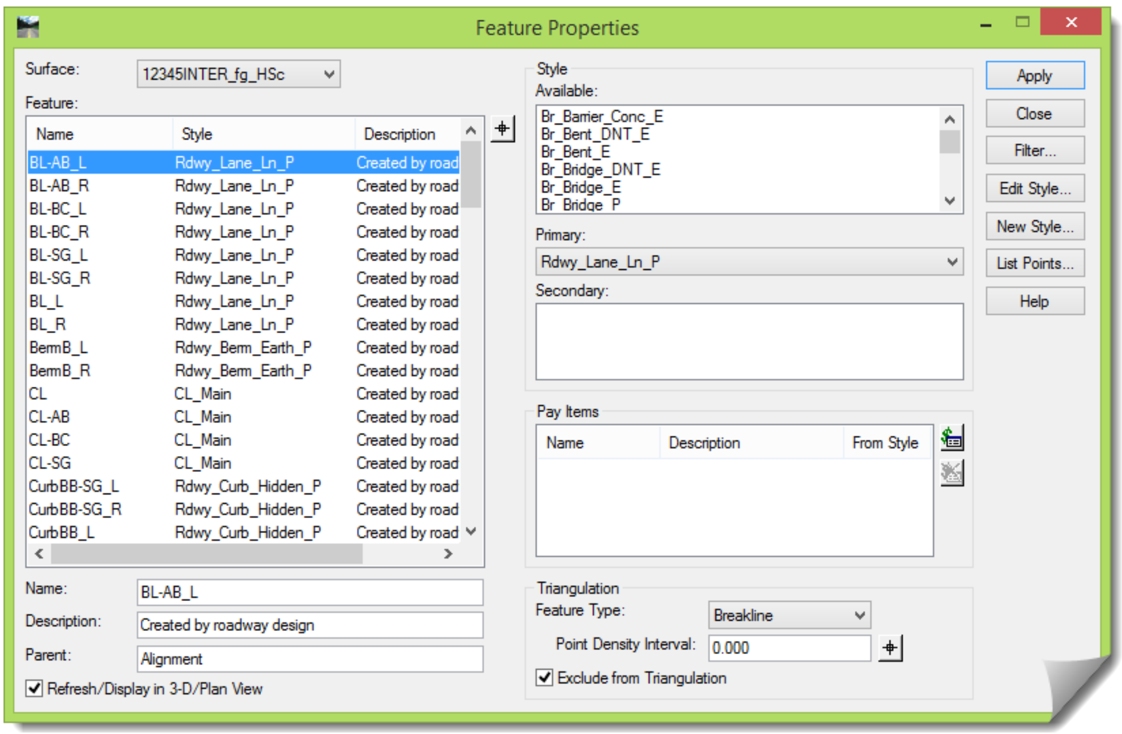
Review Design Surface

Lastly, let's look at the primary road design surface. This surface was generated from the corridor that was just reviewed in the **ROADWAY DESIGNER**.

1) Familiarize yourself with the `12345INTER_fg_HSc` design surface.

As a suggestion, do some or all of the following:

- Review the **SURFACE PROPERTIES**
- Review the **FEATURE PROPERTIES**
- **VIEW FEATURES** in plan view, taking note about how they look in the area of the upcoming intersection and approach area.
- **VIEW CONTOURS** and **VIEW TRIANGLES**



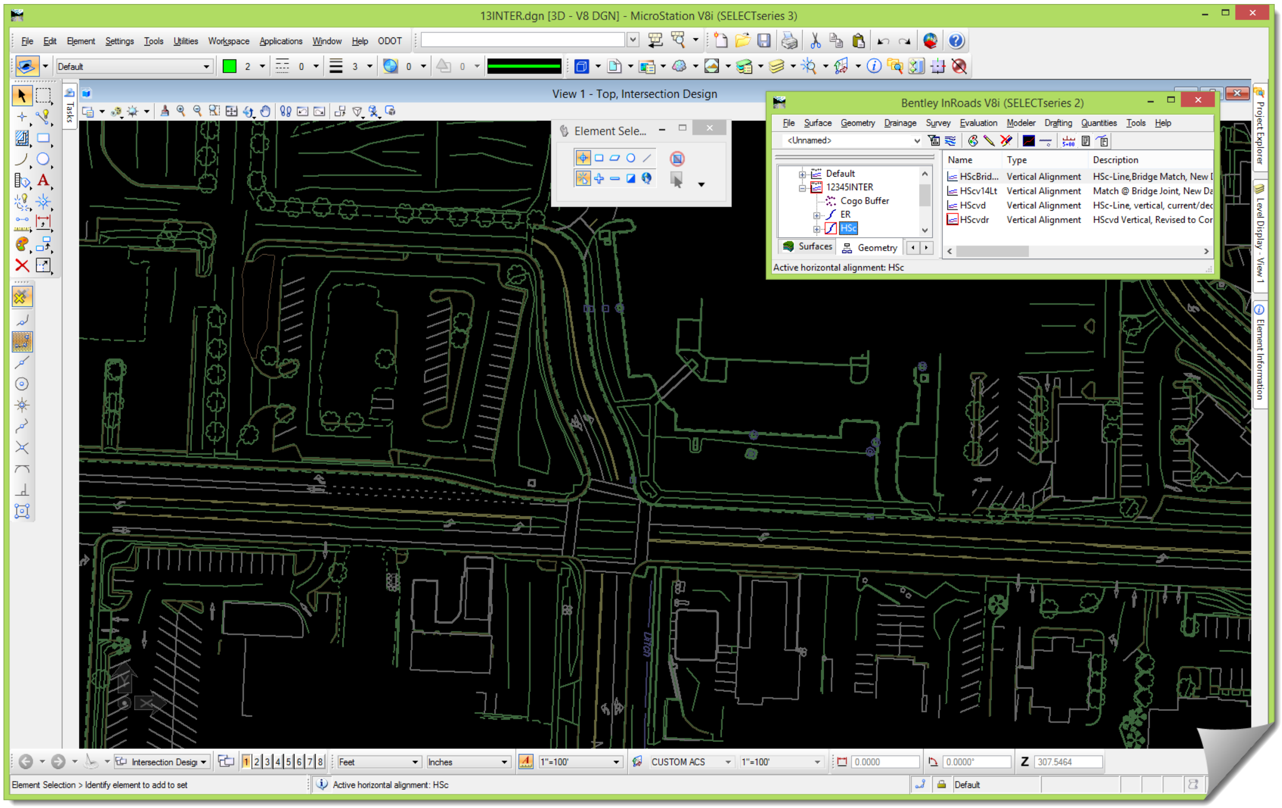
2) Before moving forward, [**Close**] any open dialog boxes and delete any MicroStation graphics that you may have displayed.

Move forward with a clean MicroStation file. Unless specifically instructed, it is your option to turn *on* or *off* any reference files or MicroStation Levels during this module as you feel the need.

SCENARIO 1 - NORTH INTERSECTION

This first scenario will work on the intersection of **ER** on the north side of **HSc**.

1) Make sure that the only reference file turned on is **12345eF** and you are windowed into the area of the intersection.



To get started, the initial corridor for the primary road was created without considering the intersection location of any side roads.

As a side note – with the foresight that you will have after studying this module, in anticipation of future work on a primary corridor you *could* strategically drop templates at any anticipated return PCs or PTs. However, later they will be located with precision once the returns are built (both horizontally and vertically), so in this case we have not done this.

Also note that the intersection returns can be built horizontally at this point if the horizontal alignment of the secondary road is done (which is often the case). If the returns are built horizontally, the exact PC and PT stations can be identified for additional drops along the primary roadway. However, the vertical alignments for the returns cannot be created until the vertical alignment for the secondary road is done. The vertical alignment for the returns is not done until the primary road is modeled so the secondary road vertical alignment can be properly tied into it.

Sequence-wise, once the primary road design model is created and reviewed, the geometry for the secondary road can be created, followed by the return geometry.

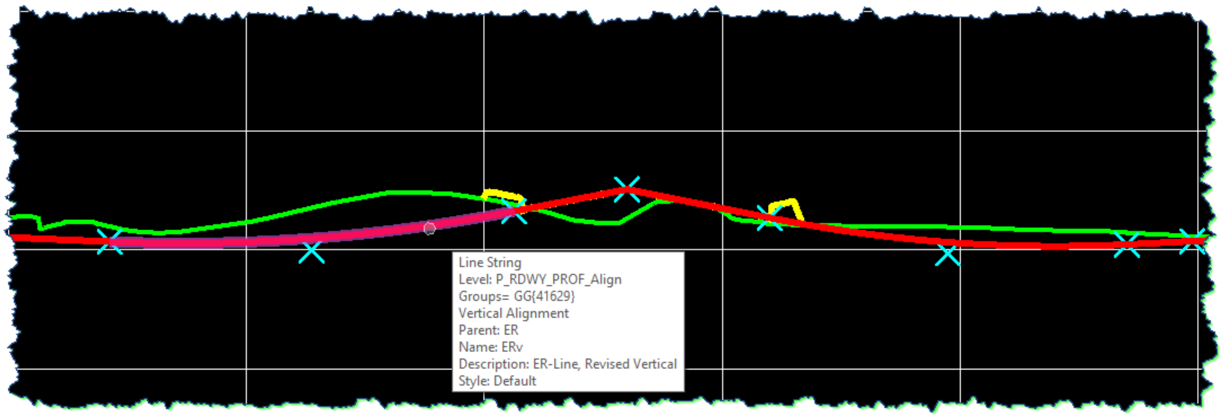
In this module, both the horizontal and vertical alignments for the secondary road have also been created to expedite this modeling. It is assumed that anyone working through this module already has that layout expertise.

Let's review and verify the secondary road geometry before moving forward.

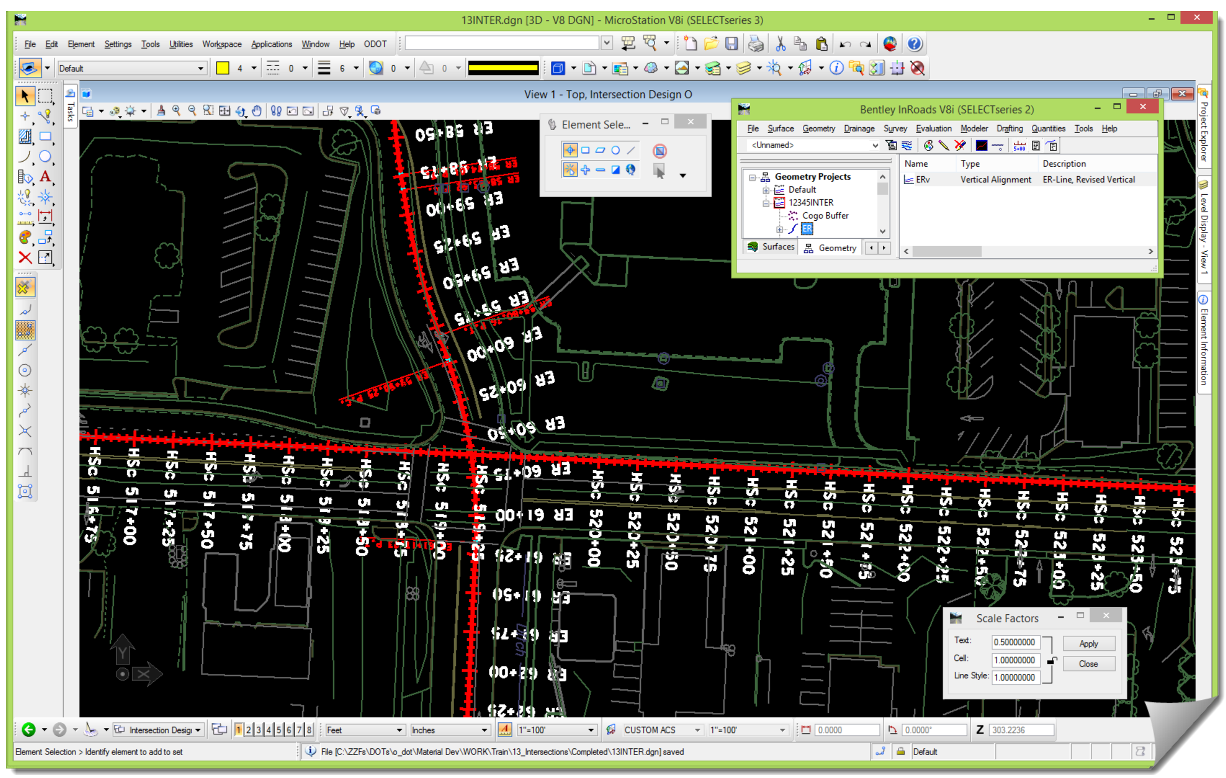
2) Create a Profile for the secondary road along its centerline.

View the original ground as well as the primary road design surface.

3) Review the vertical alignment, making sure that it ties into the primary road design model.



4) For orientation, establish some appropriate settings and view the **ER** horizontal alignment and stationing, along with the **HSc** alignment and stationing.



Let's discuss how the secondary road modeling will be broken up. First, notice that the direction of the **ER** alignment is running north to south. Since the focus of this module is on the intersection itself, this modeling will be broken up this way:

a. Scenario 1 will model the northerly portion of **ER** from Station **58+00** to about **60+50**.

b. Scenario 2 will model the southerly portion of **ER** from about Station **61+00** to **62+50**.

The focus moving forward will be the northerly portion. The southerly portion will be added in Scenario 2, followed by a primary road approach added in Scenario 3.

Intersection Returns

Once the horizontal and vertical alignments are complete for both the primary and secondary roads, the intersection return alignments can be constructed. The purpose will be to use them as controls in the **Roadway Designer** later, allowing us to model around those returns.

For this module, the EP will be used as the return control line; however, the gutter or any other point could be used instead. An important aspect of defining your control is to correctly identify the horizontal width and vertical position for the newly developed return geometry.

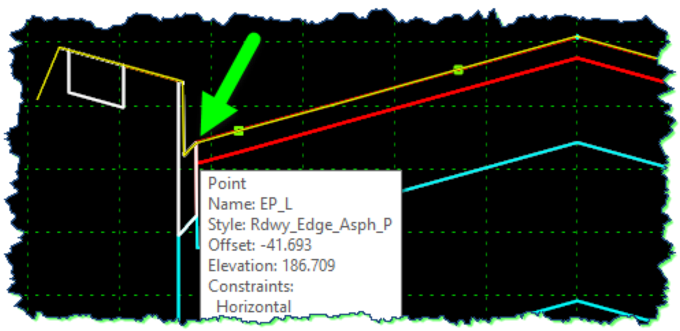
1) Go to the **Multicenter Curve** tool under ***Geometry > Utilities***.

You will be constructing the horizontal and vertical alignments for the northerly returns only.

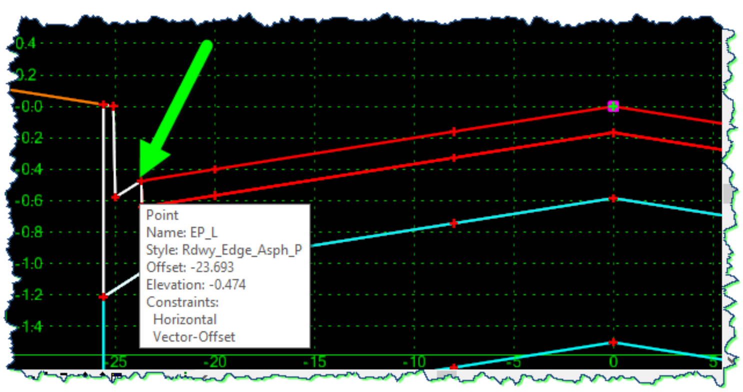
TIP: The **Multicenter Curve** tool can construct **One Center**, **Two Center** and **Three Center** curves. The dialog box is intuitive and only requires referencing the graphical representation of the curve, and an awareness of the **Alignment 1** and **Alignment 2** designations.

2) Set up the command to create the **ERnw** return using this horizontal criteria:

- **Alignment 1** will be the primary road, **HSc**
- **Alignment 2** will be the secondary road, **ER**
- **Width 1** = **41.693′** (determined by the offset of the **EP_L** in the **Roadway Designer**)



- Width 2 = **23.693′** (based on the offset for the **EP_L** of the **ER-Line** template)



- Radius 1 = **76.404′** (**75′** radius to the top face of curb, **CurbTF**, plus **1.404′**)

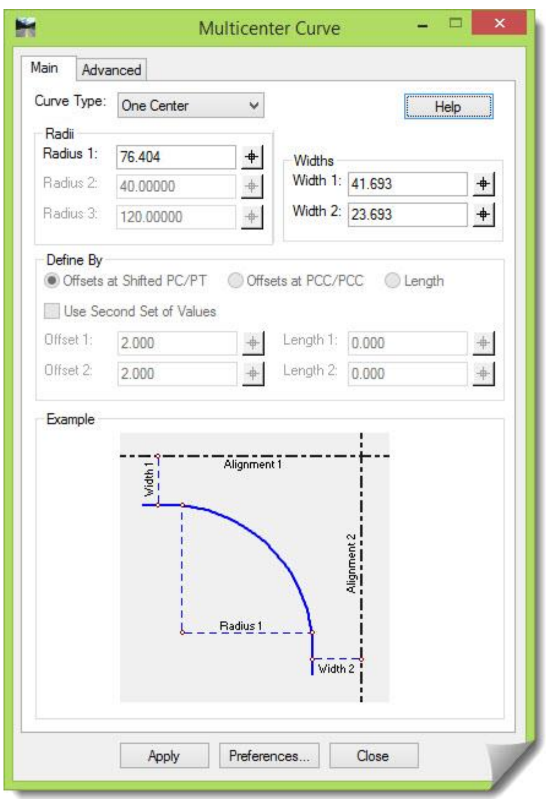
For the purposes of this module, a very simple curve will be created. On your project, you should use whatever curve geometry is required. Know that you are not required to use this tool to create these returns. Any horizontal or vertical technique will work since the end goal here is just to create horizontal and vertical alignments to control the transition between these two roads.

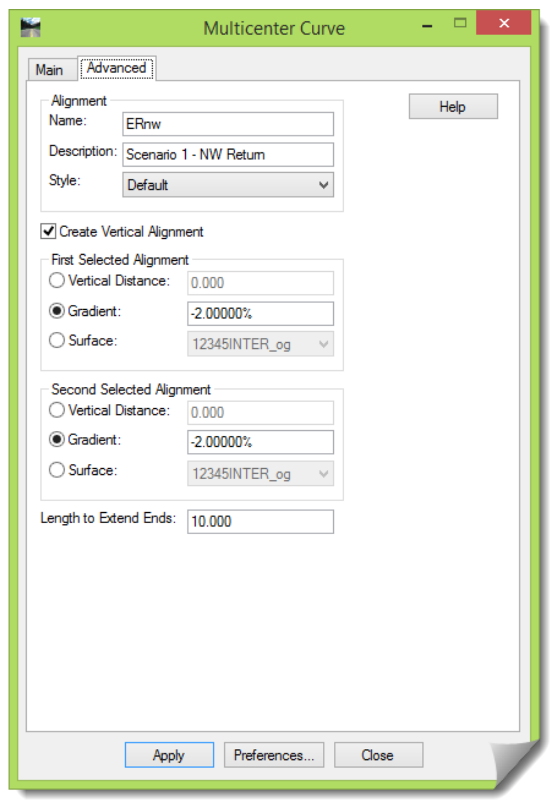
3) Go to the **ADVANCED** tab and establish these settings for the vertical alignment:

The **Name** given here will become the name for both the horizontal and vertical alignments. In order to have a different vertical alignment name, like **`ERnwv`**, you'll have to go to the **RENAME GEOMETRY** command and rename it after it's been created. (Feel free to do this in this module on your own.)

- **Name** = **`ERnw`**
- **Description** = (**`Something appropriate`**)
- Toggle *on* to **Create Vertical Alignment**
- **First Selected Alignment** set to **Gradient** = **`-2.00%`** (based on template cross slope, and accounting for any Superelevation that may be occurring adjacent to the return).
- **Second Selected Alignment** set to **Gradient** = **`-2.00%`** (based on template cross slope, and accounting for any Superelevation that may be occurring adjacent to the return).
- **Length to Extend Ends** = **`10'`** (this extension is only applied to the vertical alignment)

The settings on the **MAIN** and **ADVANCED** tabs should look like this:





4) [**Apply**] the command and follow the prompts. Take care to select the primary alignment as **Alignment 1** and the secondary alignment as **Alignment 2**.

If you are unfamiliar with this command, here is the sequence of the prompts that you will see in the lower left of the MicroStation frame.

a. *"> Identify first alignment/Reset"*

b. *"> Identify second alignment/Reset for new first alignment"*

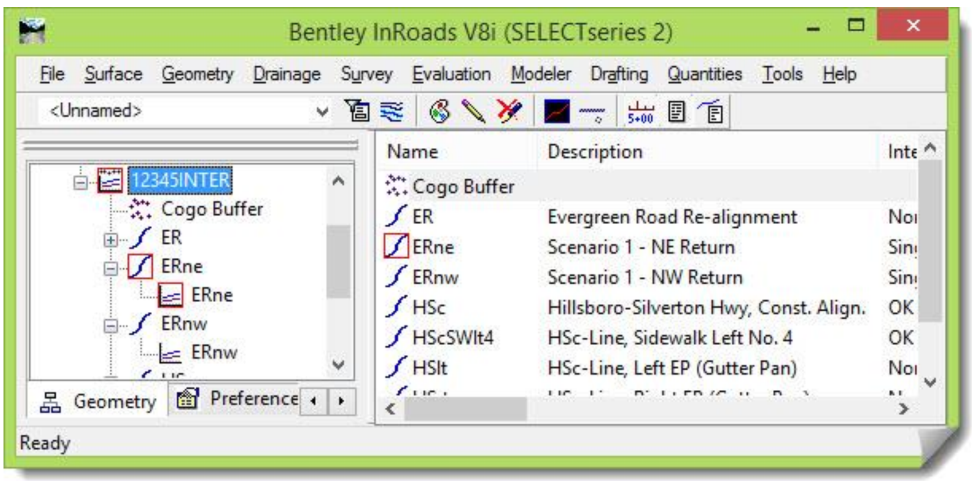
c. *"> Identify quadrant for return/Reset for new second alignment"*

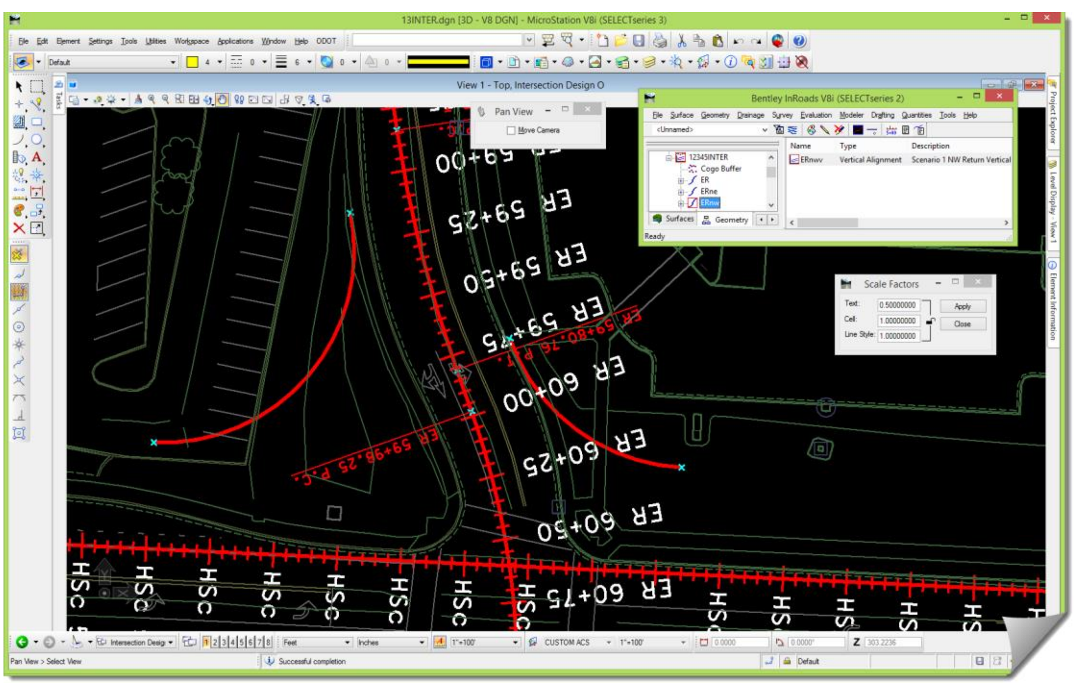
d. *"> Accept/Reject"*

TIP: The **MULTICENTER CURVE** command is one of those tools that steps through a specific sequence of prompted requests. At any time you can <**Reset**> and back up a step. At the end of the command execution, you must 'back out' of the tool step by step in order to exit it.

TIP: At the end of the **MULTICENTER CURVE** command, once the new return is accepted, a prompt to *identify quadrant* appears. If the other returns have the exact same geometric criteria, those other quadrants can be selected to quickly create those returns. Note incremental geometry naming will occur, potentially requiring the geometry to be renamed.

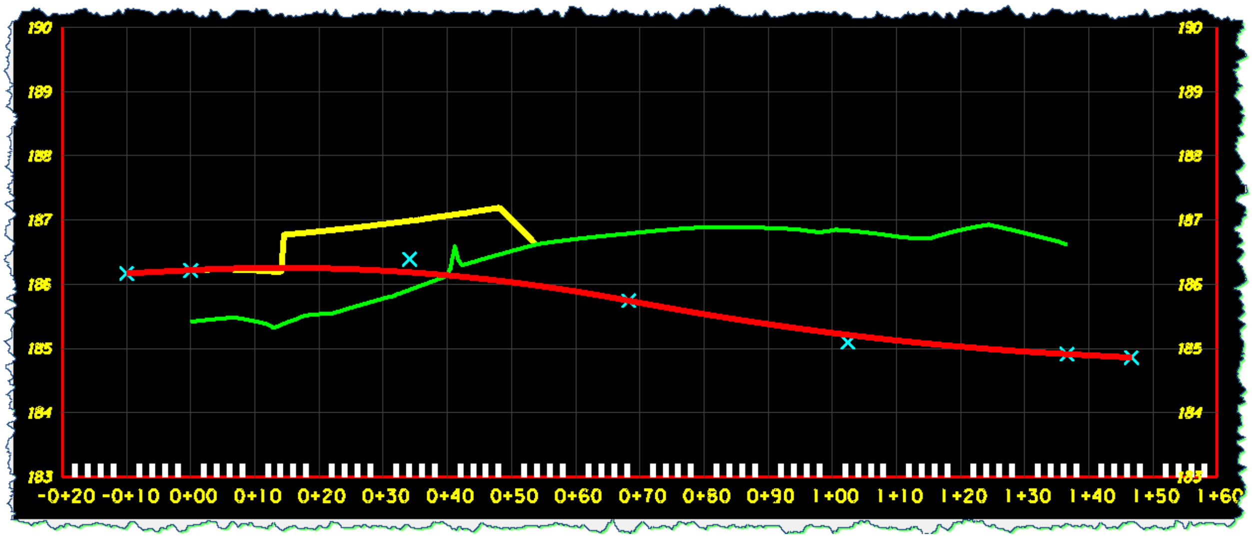
5) After the first return is created, use the same layout criteria and create the other return called **`ERne`**.
6) Verify that both return alignments have been created.

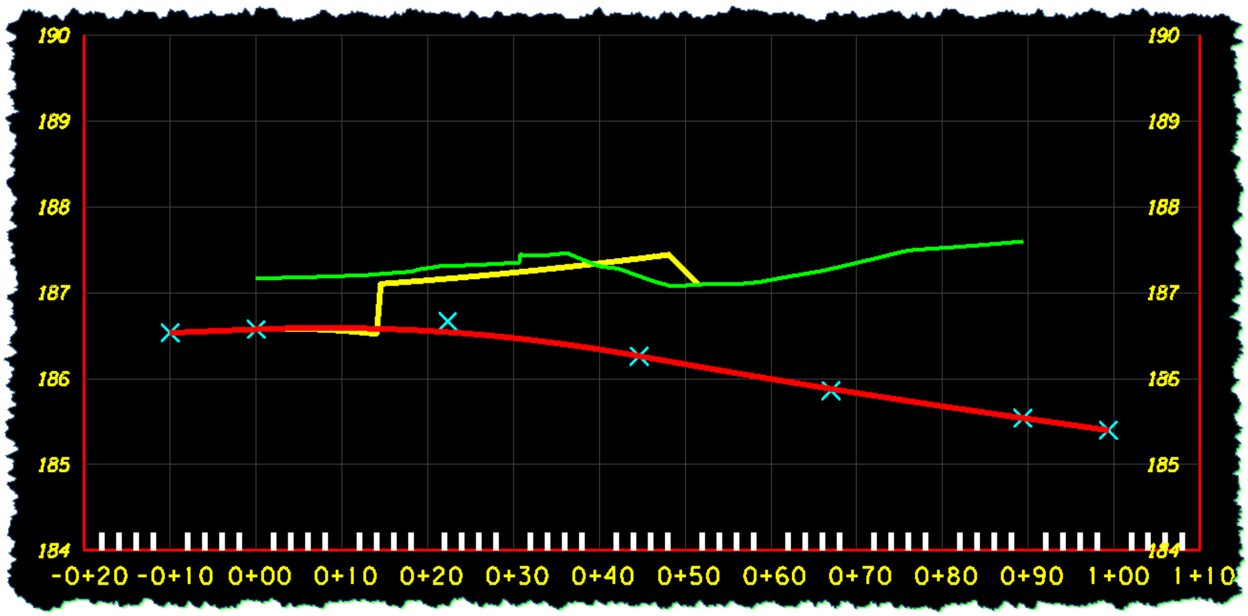




7) Create a Profile along the return horizontal alignment and view the vertical alignment for each return.
8) Review the vertical alignments and check for positive drainage around the returns.

Note that at this point if any drainage or ADA-compliant cross slope issues expose themselves, use the vertical design and editing tools to modify the vertical alignment to address the problems.





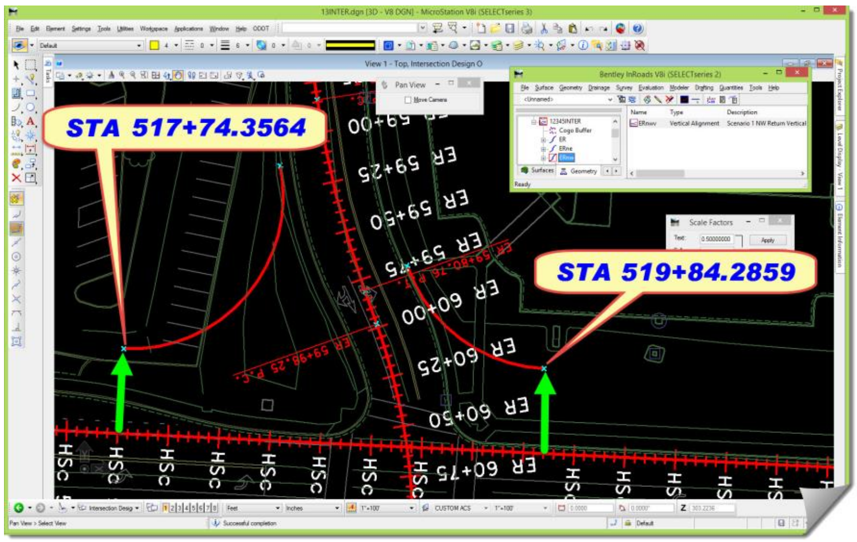
Station Identification for Corridor Edits

Now, based on these new returns, the primary road stationing for the start and end of the new template that will run through the intersection can be defined.

This can be done using a method like **Horizontal Tracking** or **General Tracking** to identify the primary road stations for the northwesterly return PC and the northeasterly return PT.

1) Using some method that you are comfortable with, determine the stationing along the primary road where the intersection returns tie to the **EP_L**.

2) The primary road stationing that was determined is:
   - **`517+74.3564`** at the start
   - **`519+84.2859`** at the end



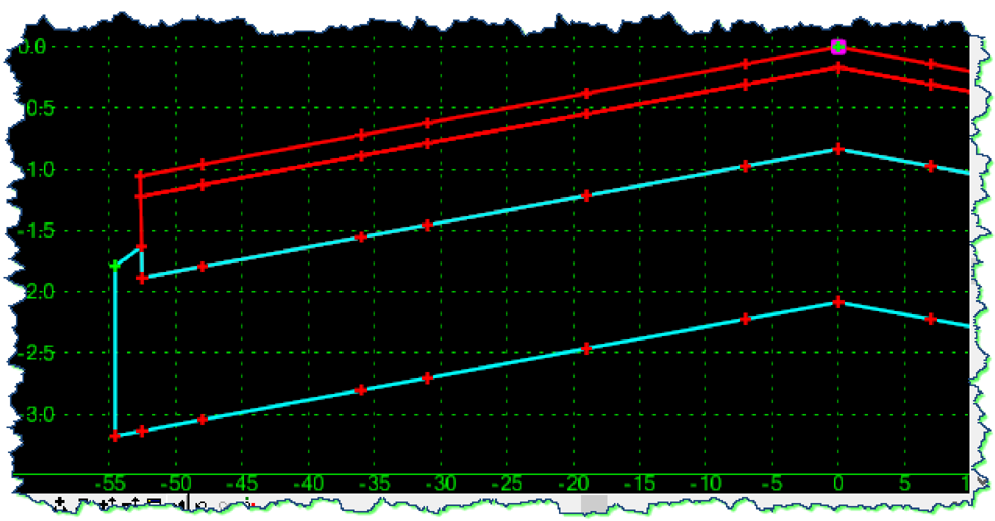
Enhancing the Primary Corridor

1) Open the **Create Template** command and browse to the **Templates** folder.

   A new template will be created for this stretch of *primary* road. The ECs, curbing and sidewalk will not be running through the intersection with the secondary road. This is done here with the templates to eliminate partially deleting breaklines in the surface later, as was done with the driveway modeling in Module 9.

2) Copy **`HSc_MainGut`** to **`HSc_MainGut_ERn`**, edit the **Description**, and remove the EC, sidewalk, planter, and curb & gutter components from the left side of the template.

   At this stage, the template should look like this on the left side:

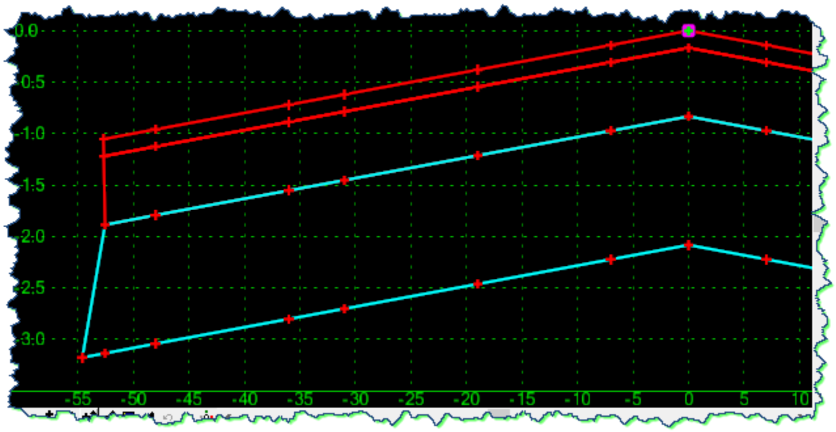


The **`AggBase`** component will be modified next, being observant not to modify the wearing course or the base course components since the curbing from the intersection returns needs to marry up with this section.

The sequence for the next few steps in this module is not rigid, as there are other ways to accomplish the same result, which is to remove the **AggBase** under the earlier curb location while retaining the integrity of the wearing and base course components.

3) Delete the **CurbBB** and **CurbBF** template points.

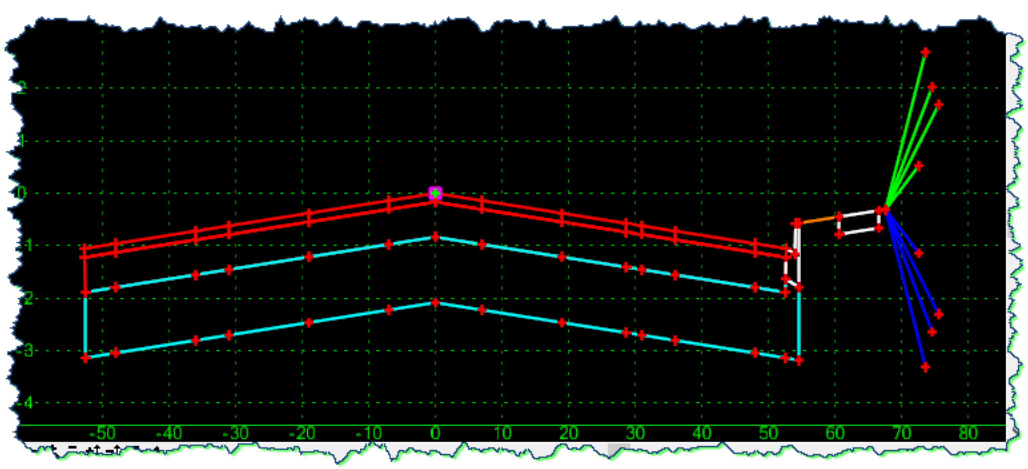
These instructions are in generic terms (not designating **_L** and **_R**) to steer you away from being too rote in future applications.



4) Delete the **CurbBB-SG** template point.
5) Edit the following template points as noted here (establishing **Horizontal** and **Vertical Constraints** for each point):
   - **EP-BC** should be horizontally directly under the **EP**.
   - **EP-AB** should be horizontally directly under the **EP-BC**.
   - **EP-SG** should be horizontally directly under the **EP-AB**.

ALERT: There is always the potential for un-constraining points when you edit and / or remove components from existing templates. Be attentive to this and be sure to address these points appropriately if you see them.

The revised template should look like this:



6) [**Save**] and [**Close**] the **Create Template** tool.

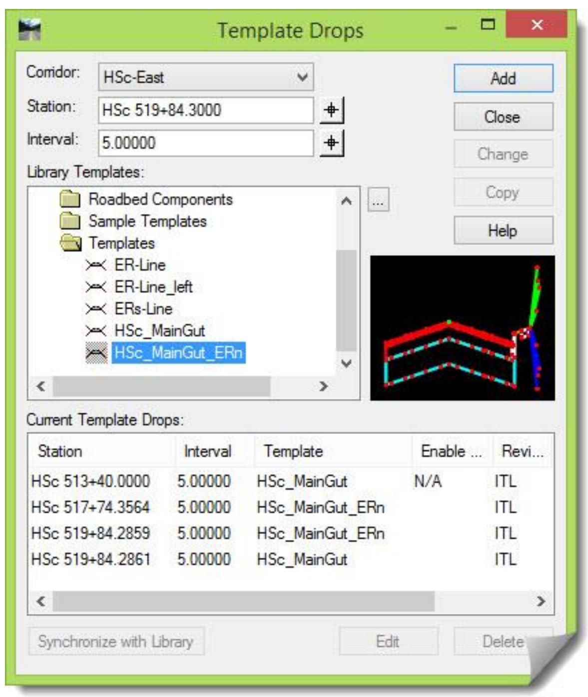
7) Go to the **Roadway Designer**, set the *primary* corridor (**`HSc-East`**) *active*, and then open the **Template Drops**.
8) Add a template drop with the newly created 'intersection' template at the station that coincided with the NW return PC at the start of the intersection.
9) Disable the transition on that new entry.

The section between this drop and the next is not a transition so the **Enable** should be *off*.

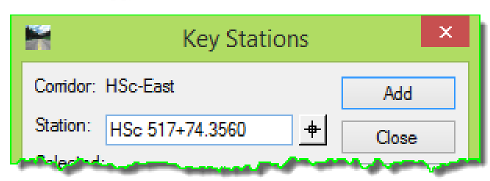
10) Add another template entry with the same 'intersection' template at the station on the other end of the intersection.

> **ALERT**: The precision of the inputs shown throughout this module may not always be consistent with the values shown in the steps. Do not be alarmed by this, the decimal precision, discussed in more detail later, is often adjusted while working with InRoads.

11) Lastly, either select the first entry in the **Current Template Drops** list and [**Copy**] it to **Station `519+84.2861`**, or just [**Add**] another entry with the **`HSc_MainGut`** template at that station to create an abrupt transition between the two different templates.
12) Disable the transition on that new entry, and verify your entries with those shown below.



13) [**Close**] the **Template Drops** dialog.
14) **Add** a **Key Station** at **Station `517+74.3560`** to introduce a modeling drop prior to the intersection, and carry forward the template dropped at `513+40`.



This is needed since the modeling interval is `5.00'`, which would place the last full template drop at `517+70`. A **Key Station** will continue the full road section modeling right up to the intersection.

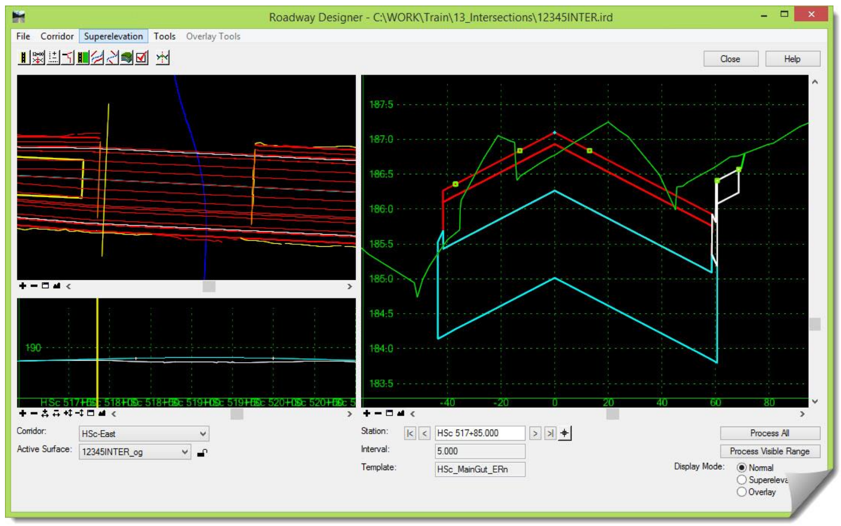
15) [**Save**] the IRD.

16) Go to ***Tools > Options*** and make sure the **Include Critical Sections** options are all toggled *on*. This will improve the modeling accuracy within the **Roadway Designer**.

Make sure these options are toggled on throughout this module; otherwise, your results may not be the same as shown here. Make sure you understand the implications of each toggle option.

17) [**Process All**] and review the results in the **Roadway Designer** views.

Notice the plan view cutout where the curb & gutter and other outer components are no longer included. This is observable in the cross section view as well. This is where the secondary road (with its returns) will join into the primary road model.

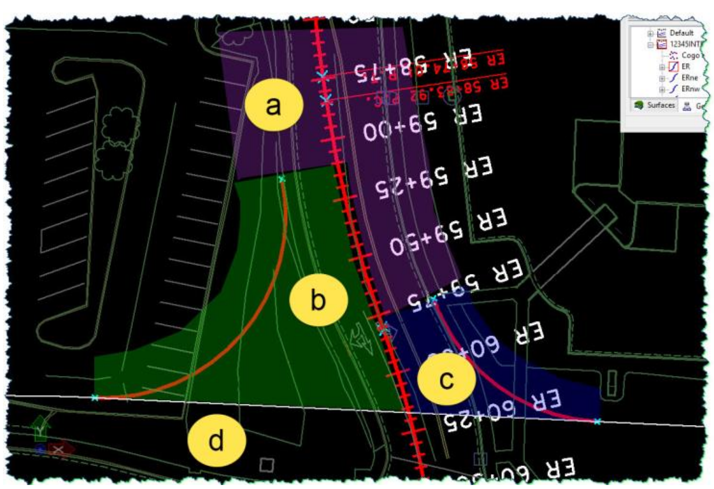


Building the Secondary Corridor

The following methodology applies particularly well to skewed intersections. This is discussed and expanded upon in *Other Details* at the end of this module.

The approach is to model the secondary road in three pieces, in separate corridors.

a. The principal roadway on both the left and right sides, up to the first return
b. The NW return
c. The NE return



Then, using the strength of the **Roadway Designer**, these three separate corridors will be combined along with the primary corridor to produce a single surface.

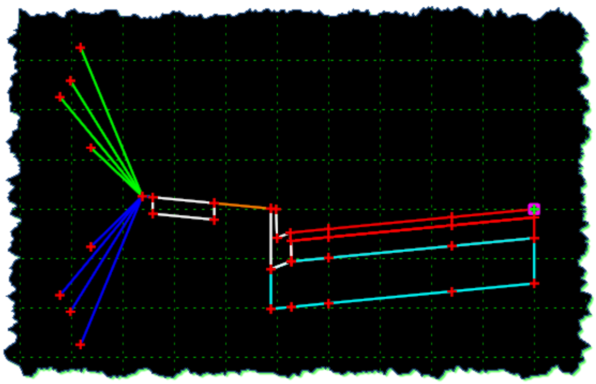
There can be variations on this where the secondary road corridor "**A**" is carried to the primary road and the return modeling is confined to the **`EP`**s of the secondary road as well as the primary road.

Moving forward, the main template for this roadway has already been created in the template library – **`ER-Line`**. This template will be used to create an additional template that will only contain the left, or east, side.

1) Open the **CREATE TEMPLATE** command and browse to the **Templates** folder.
2) Copy **`ER-Line`** to **`ER-Line_left`**, and remove the entire right side.

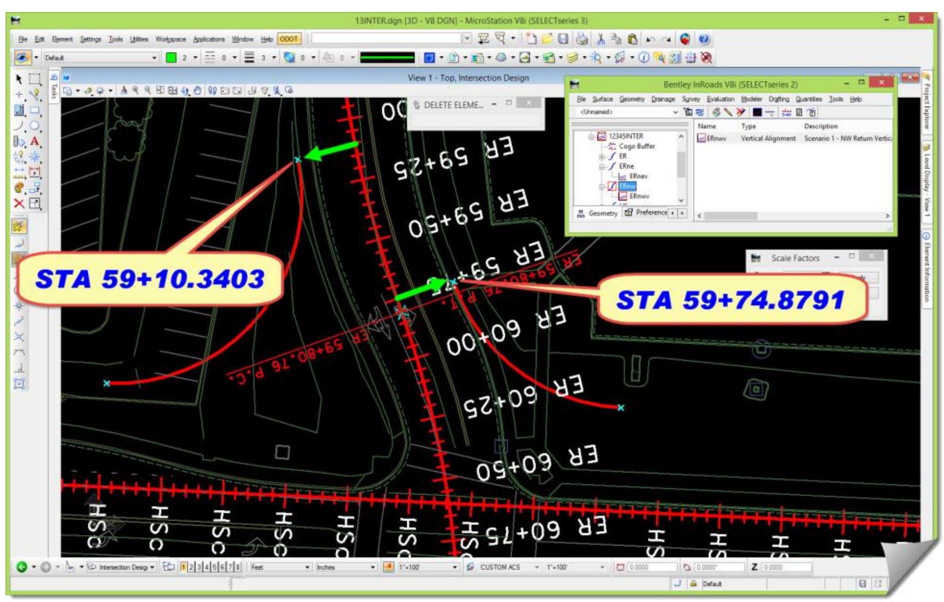
> **NOTE**: Although merging components together makes for a cleaner looking template (like was done in the pavement section of this template when it was created), it makes modifying them later a bit more difficult and involved.

The revised template should look like this:



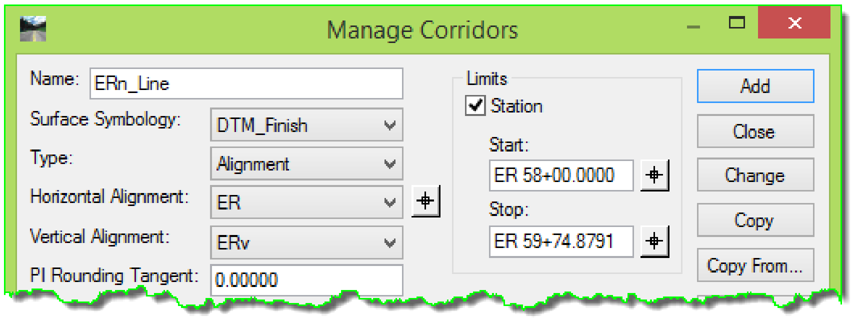
3) [**Save**] and [**Close**] the **CREATE TEMPLATE** tool.

Earlier, stationing was determined along the primary road in reference to the new return geometry. The same thing was done here, and below are the results. We'll need this information when setting up the secondary road corridor, and precise stationing extraction skills are valuable.

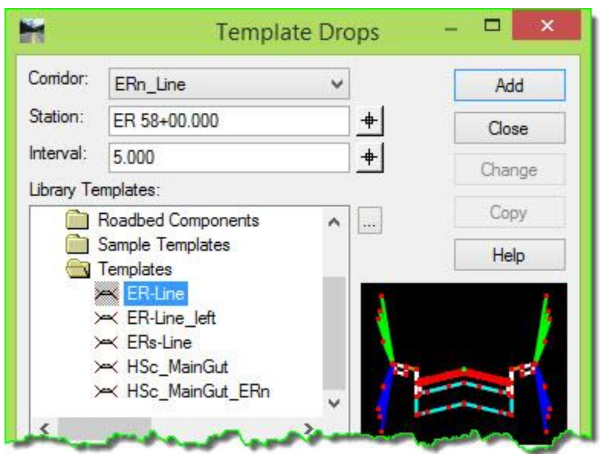


4) Go to the **Roadway Designer**, and create a new **Corridor** called **`ERn_Line`** as shown:
    - **Start Station** = `58+00.0000` (an arbitrary start of the corridor)
    - **Stop Station** = `59+74.8791` (the station where the full road encounters the NE return)

Additional commentary on this **Stop Station** is in *Other Details*, the last section of this module.

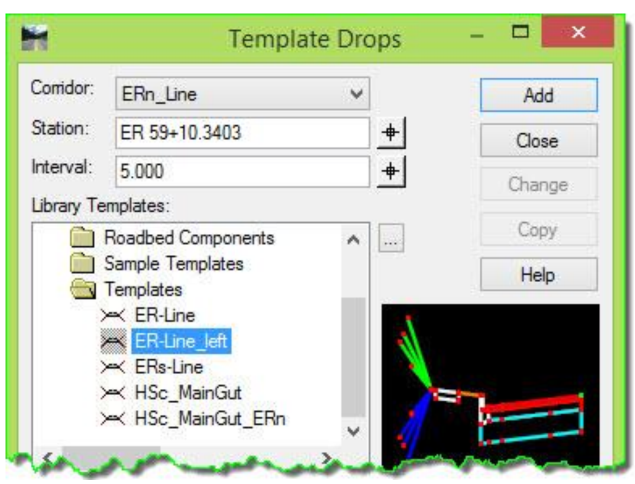


5) [**Close**] and then open the **Template Drops**.
6) [**Add**] the first template drop using the full section at the start of the alignment.



7) Next, [**Add**] the **`ER-Line_left`** template at **Station** `59+10.3403` to model the southerly west side of area '**A**' shown earlier.

Make sure you are referring back to earlier diagrams and instruction so you understand why these values are being used here. If you are not following the entries that you are adding, do not move forward. Go back and review earlier material until you understand why this is being done this way.



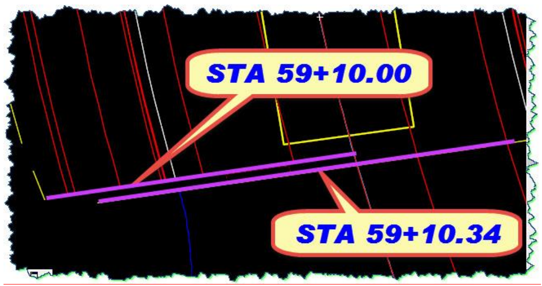
8) Disable the transition on this entry.

This can be disabled since the template drop prior to this one is essentially the same template (at least on the east / left side), so whether the transition is abrupt or gradual would make no difference in this modeling.

9) [**Close**] the **TEMPLATE DROPS** dialog box, [**Process All**] and review the results.

If you review the model, see if you can tell that the right side (west side) modeling is stopping short of the return at station `59+10.00`. It's barely noticeable because it's so small; however, it can be seen if you zoom into that area.

That is the last full section on the west side before it jumps to the half section at `59+10.3403`. Because of the modeling interval, this will need to be addressed; otherwise, there will be a gap in the modeling of the components between the end of this corridor and the return corridor.

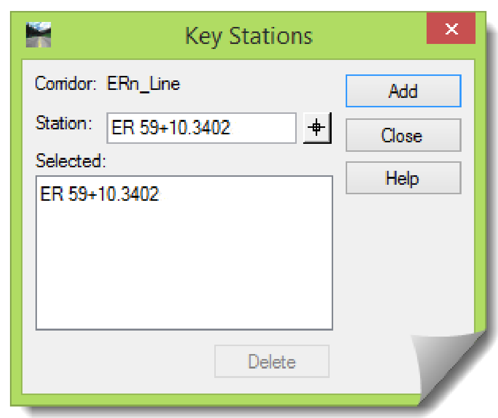


10) [**Add**] a **KEY STATION** at `59+10.3402`.

Consider this an expanded tip:

The addition of a template drop just prior to a template change where an abrupt transition is desired is very common. This technique is done for a number of reasons:

- It's easy for others to intuitively observe what's happening
- Template Drops are often reviewed when familiarizing yourself with a project
- It provides an opportunity for future editing and control
- It's historically something that experienced users have being doing for some time



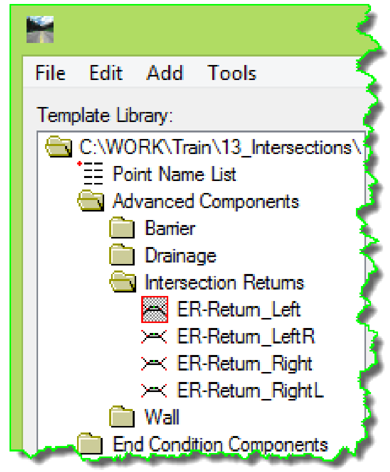
However, there is another way to accomplish the same thing – a **KEY STATION**.

The addition of a **KEY STATION** tells InRoads to process a modeling section at that location. This entry will produce the same results in this corridor as the earlier template entry.

11) [**Close**] the **KEY STATIONS** dialog box, [**Process All**] and review the results.

The modeling should now continue to the beginning of the returns on both the left and right sides of the secondary road.

TIP: Practice reviewing the modeling results in the **ROADWAY DESIGNER** views. True, it's not like reviewing the resulting surface information in MicroStation with all of its referencing capability, but with close attention, it can be sufficiently revealing.



Intersection Return Modeling

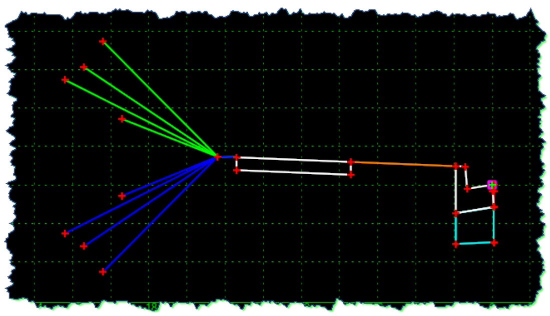
Now, modeling the returns will be the focus.

1) [**Save**] and [**Close**] the **Roadway Designer**, and open the **Create Template** tool, or just go directly to the templates from the **Roadway Designer** menu.
2) Browse to the **Advanced Components** folder and then to the **Intersection Returns**.

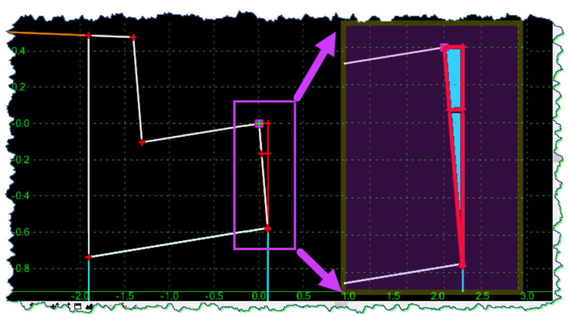
The templates here have been created based on these project sections, but can also be used as reference for future project templates, or modified to suit your needs.

3) Do a review of these templates at the level of your skills.

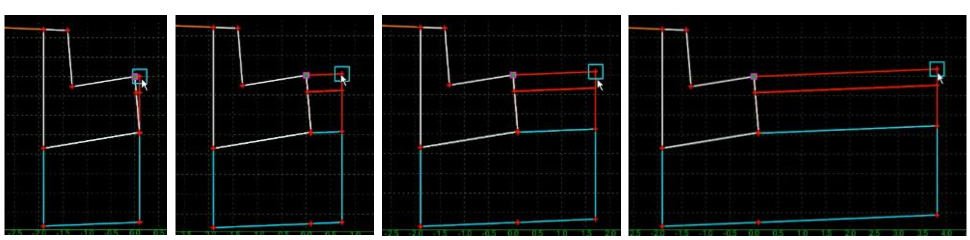
They are all essentially the same, with naming variations depending on which side of the model they are used on. There will be more about why these naming variants were developed shortly, but for now, walk through the next few steps to gain some insight into their application.



4) Zooming into the gutter area shows a significant detail of these templates.

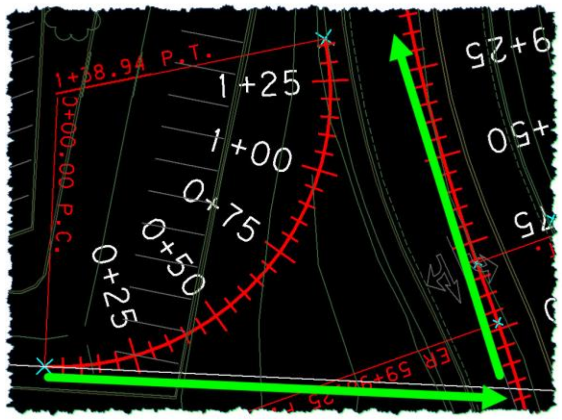


5) Use the **Test Point Controls** on that front point to see the reaction of this template.

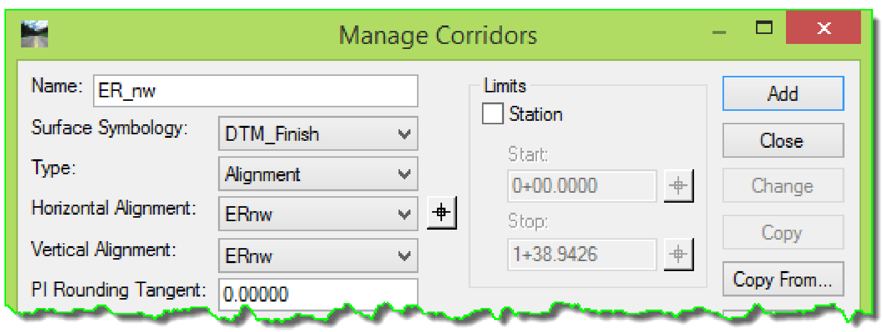


In addition to the functionality illustrated above, there are **Display Rules** attached to some of these components, as well as several component Parent-Child relationships. Feel free to explore this level of configuration if you are comfortable with it. It would be important to understand this level of functionality for debugging and editing purposes; however, it is not necessarily critical for utilization, especially in this module.

In this scenario, the template will run along the horizontal and vertical alignment of the return, while the outer point of the template is attached as a **POINT CONTROL**, first to the primary road **`EP`**, and then to the secondary road centerline. This will also construct the structural components.



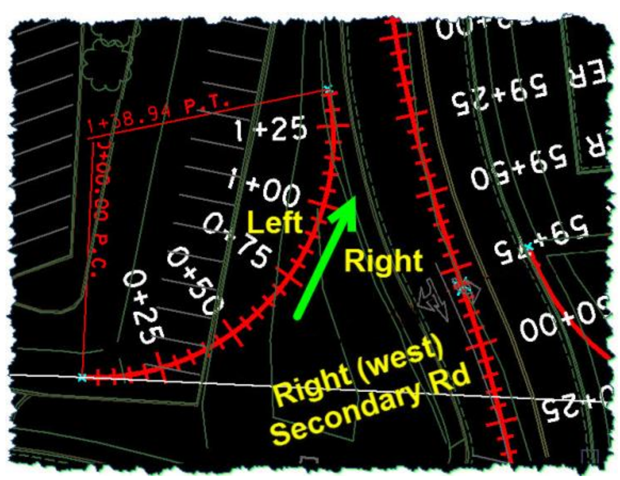
6) Close the **CREATE TEMPLATE** tool when you are done with the review.
7) Go to the **ROADWAY DESIGNER**, and create a **Corridor** for the first return called **<u>`ER_nw`</u>**.



8) [**Close**] the **MANAGE CORRIDORS** and open the **TEMPLATE DROPS**.

The point naming convention is something that has to be considered here. This intersection and these returns in particular are on the left side of the <u>primary</u> road, and therefore *could* be given a 'left' designator for that reason. They are also adjacent to the secondary road and could be oriented 'left' and 'right' from that centerline. Since these returns are being considered part of the secondary roadway model, that's what will be used here.

Now, keep something else in mind. The left (**`_L`**) and right (**`_R`**) designators are part of the template construction and point naming. Those designators really aren't aware of whether the point is actually on the right or left side of the centerline when they are used during modeling. Moreover, in this instance we are modeling from the return geometry that has its own left and right. The return left and right has nothing to do with the centerline left and right, but everything to do with which template will be run along it, and what those designators are (on the template).



Here is the thought process in this instance:

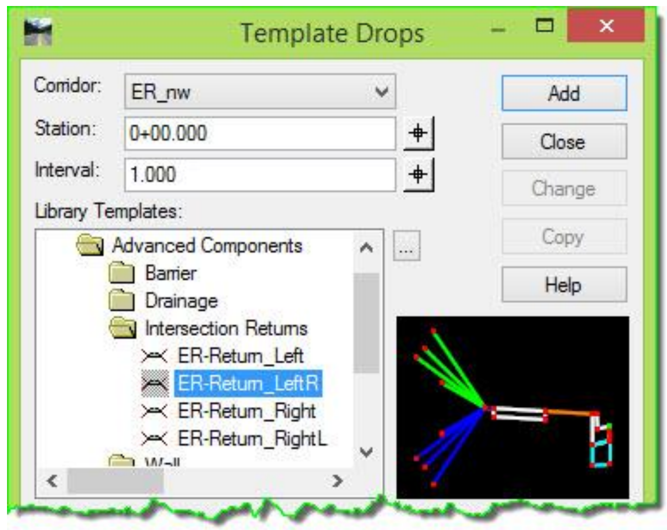
a. The first return to be modeled is on the right side (west) of the secondary road (decided to be the reference in this instance), so we want to make sure to use **`_R`** template points.
b. In this instance, the template will be primarily modeling the left side of the return alignment, so the **`_Left`** template will be used.
c. However, because the side designators (based on the secondary alignment location) need to be **`_R`**, the **`ER-Return_LeftR`** template will be used.

9) [**Add**] the **`ER-Return_LeftR`** template drop.

This template will be used along the entire return.

The way that this will be modeled is this:

a. The main return template will run along the horizontal and vertical alignments of the return
b. The outer edge of the return template, representing the pavement edge, will run along the **`EP_L`** of the primary road until it meets the secondary road
c. Then the outer edge of the return template will track along the horizontal and vertical alignments of the secondary road until it reaches the end of the return.



TIP: When establishing **POINT CONTROLS**, the **Start** and **Stop Stations Limits** can be determined by using the *Locate* / *Target* button next to those fields. Selecting that button tracks within the **ROADWAY DESIGNER** plan view window, but holding down <**CTRL**> and selecting the button allows selection to be made from the MicroStation view.

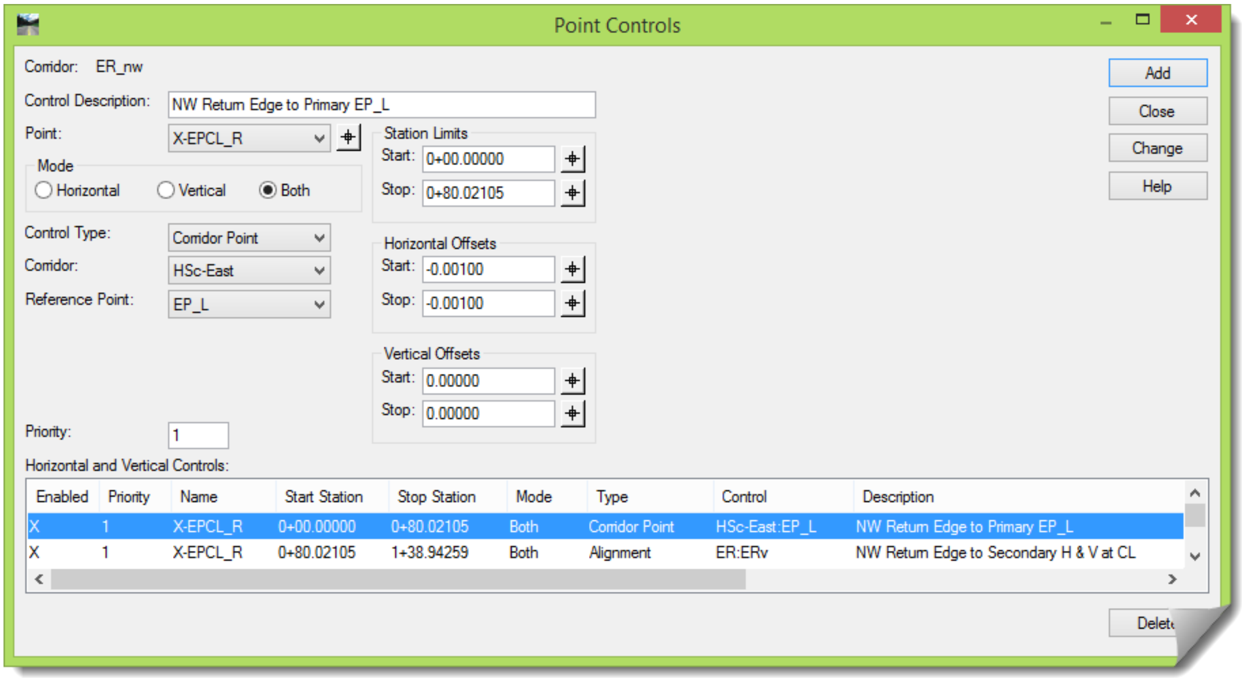
ALERT: When defining the **Start** and **Stop** locations for any **Station Limits** in the **ROADWAY DESIGNER**, it's best to use the *Locate* buttons unless you know the exact station value.

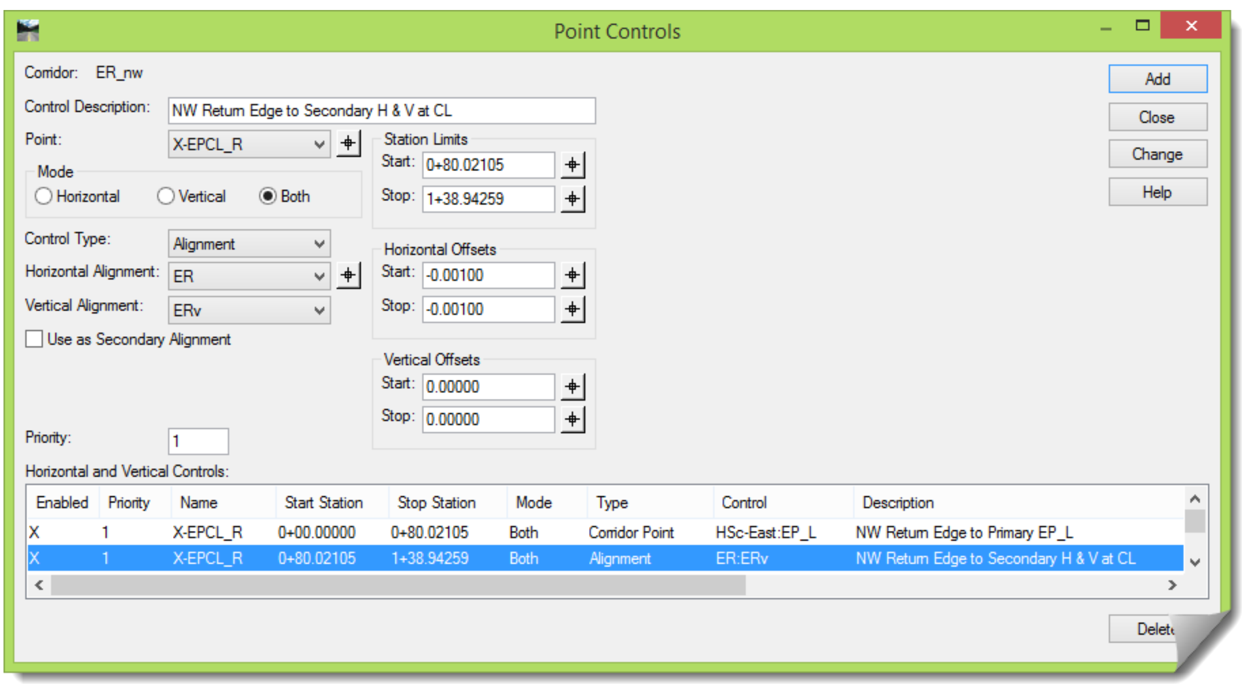
The points with the **`X-EPCL`** prefix are the potential template points that will be assigned **POINT CONTROLS**, following either the **`EP`** of the primary road or the **`CL`** of the secondary road. Note that the **Horizontal Offsets** are very slightly away from the control path. This is done to avoid overlapping breaklines with the adjacent corridor modeling.

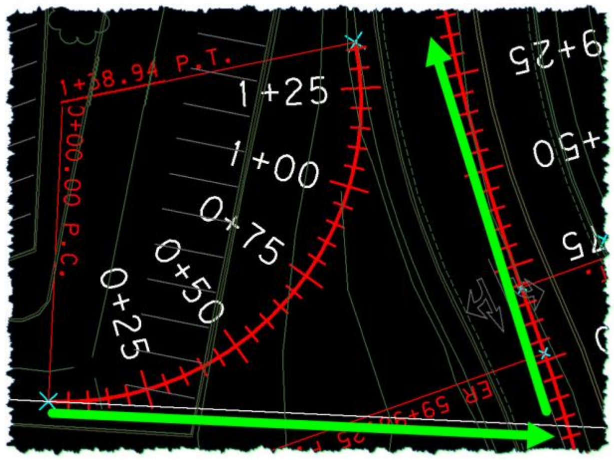
In this instance, the **`X-EPCL_R`** point of the return template is to follow the **`EP_L`** of the primary road corridor, and then continue (following another point control) along the horizontal and vertical alignment, **`ER`** and **`ERV`**, of the secondary road. These use a **Mode** set to **Both** in order to control the **Horizontal** as well as the **Vertical** location. Vertically there are no offsets applied, whereas horizontally they are offset **`-0.001`** to eliminate any duplicate breaklines.

10) Go to the **Point Controls** and add the following controls:

If you understand exactly how to create the necessary point controls, feel free to create them at this time. Otherwise, review the following dialog boxes and subsequent explanations for additional information and direction.







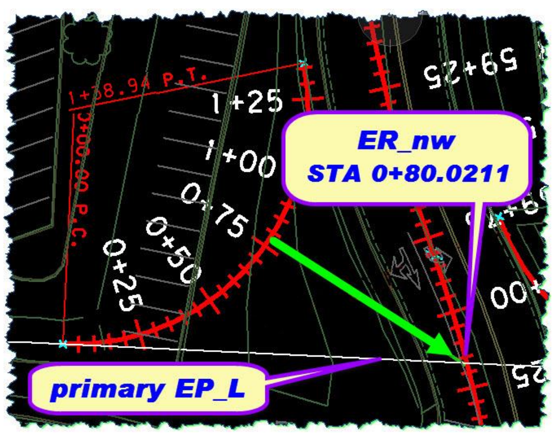
Let's discuss a few of these station entries.

The template itself will run along the return alignment.

The two **POINT CONTROLS** just created will stretch the return template edge along two controls. The first control is the `EP` of the primary road corridor. This will ensure that the return grading will match whatever the edge of pavement of the primary road is doing. The second control is the secondary road geometry. This will ensure that the return grading will match the horizontal and vertical location of the secondary road.

The most critical station here is the **Stop** on the first control and the **Start** of the second control; these are the same point. This station coincides with the intersection of these two external controls – the `EP_L` of the primary road and the `CL` of the secondary road. It's critical to get this station accurately located. One method of doing this is using the InRoads *locate button* in conjunction with the intersection snap in MicroStation to snap to the intersection of those two features displayed in MicroStation. Depending on the **Precision** defined in the InRoads **PROJECT OPTIONS**, this value (`0+80.0210515`…) may be shown as `.0211` or `.02105` or some other level of precision based on your results and other modeling criteria.

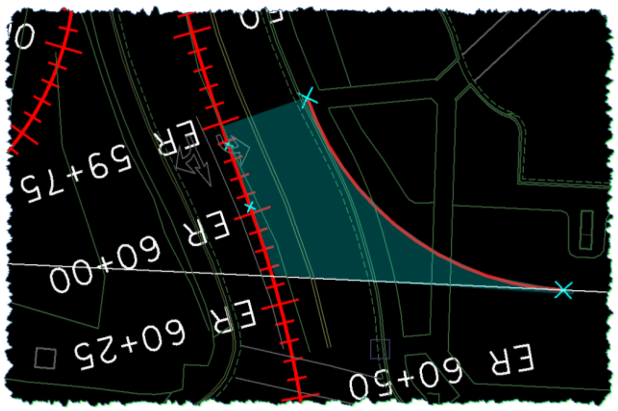
TIP: The precision shown in any numeric field is a 'rounded' value of the actual value. The amount of digits past the decimal is controlled by the **Precision** settings in the InRoads **PROJECT OPTIONS** and can be changed at any time to view a more exact representation of the number.



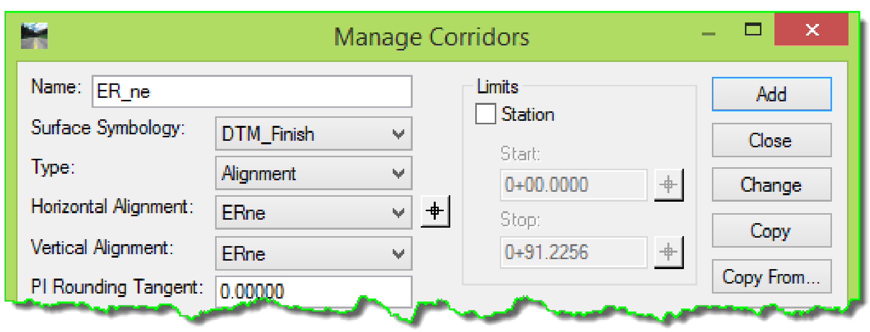
In summary, three critical stations need to be identified for these point controls:

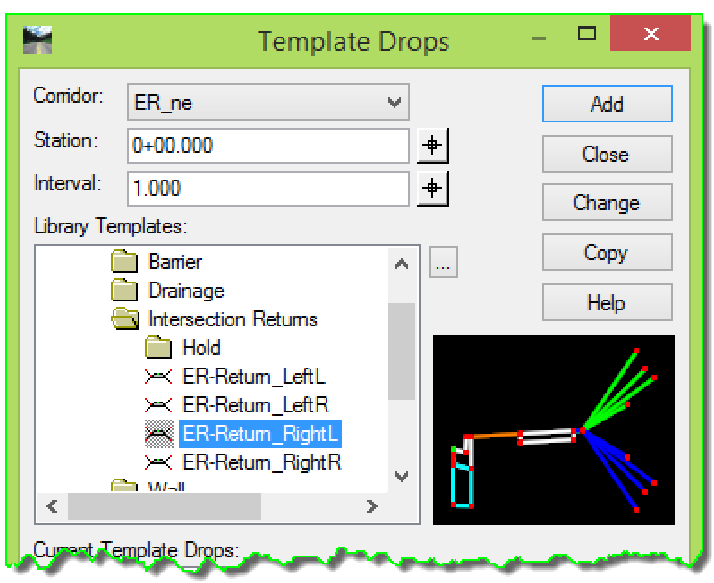
a. The **Start** of the first point control, `0+00.0000` in this case
b. The **Stop** station of the first point control / the **Start** station of the second point control, which is the station at the intersection of the primary road `EP` and the secondary `CL`
c. The **Stop** station for the second point control, which is the exact end station of the return geometry

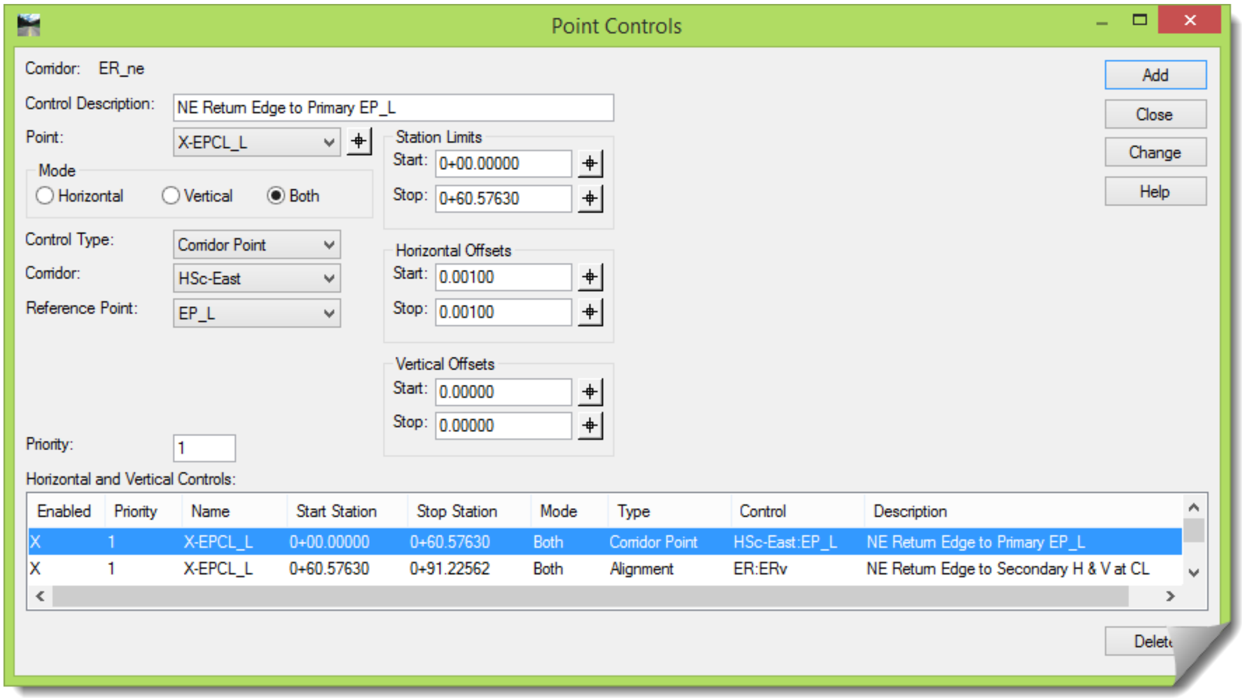
11) Now set up the modeling for the other return the same way. Here are a few tips:
- Create a new corridor.
- Think through the template direction; then do what needs done in the **TEMPLATE DROPS**.
- Modify or add the **POINT CONTROLS** to track along the primary **EP_L** and secondary horizontal and vertical centerline, making sure that the 'hand-off' stationing at the intersection of the primary road **EP** and secondary road **CL** is correct.
- Don't forget the minor horizontal offset to address any overlapping breaklines, which in this case are positive (**+**) versus the other negative (**-**) values.

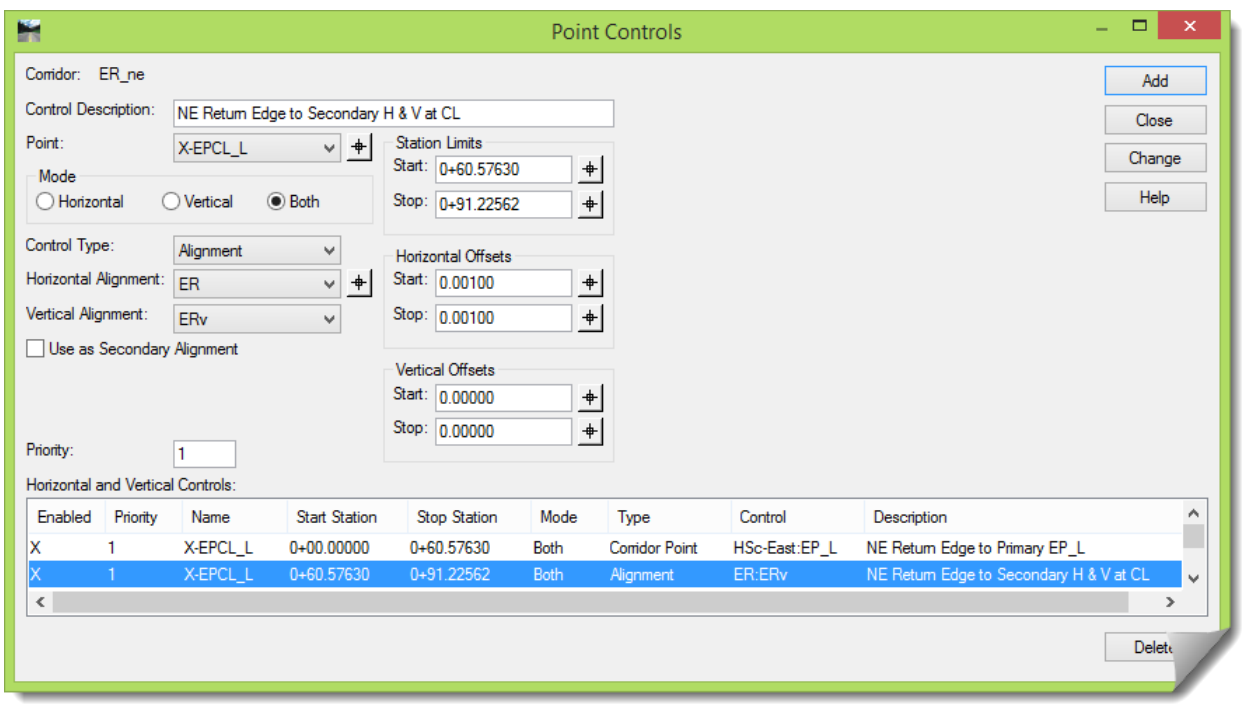


12) Compare your work to what is shown here:









13) Make sure you've saved the IRD.

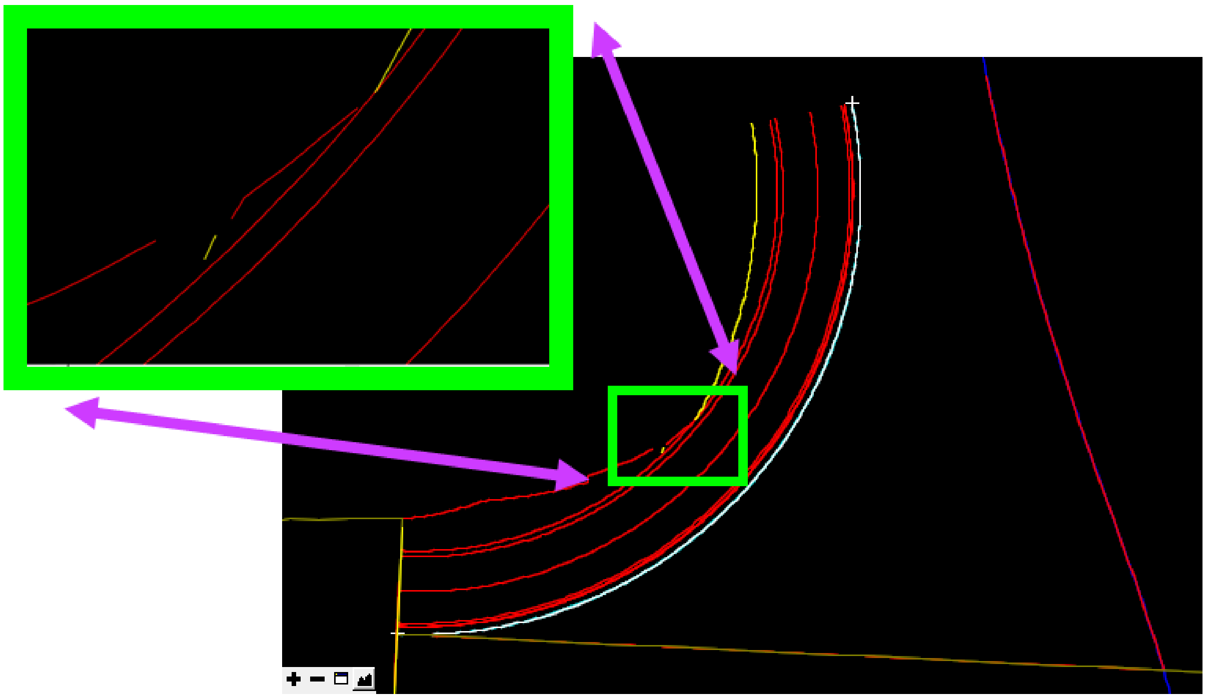
The next activity will be to combine these four corridors into a single design surface.

End Condition Clean-Up

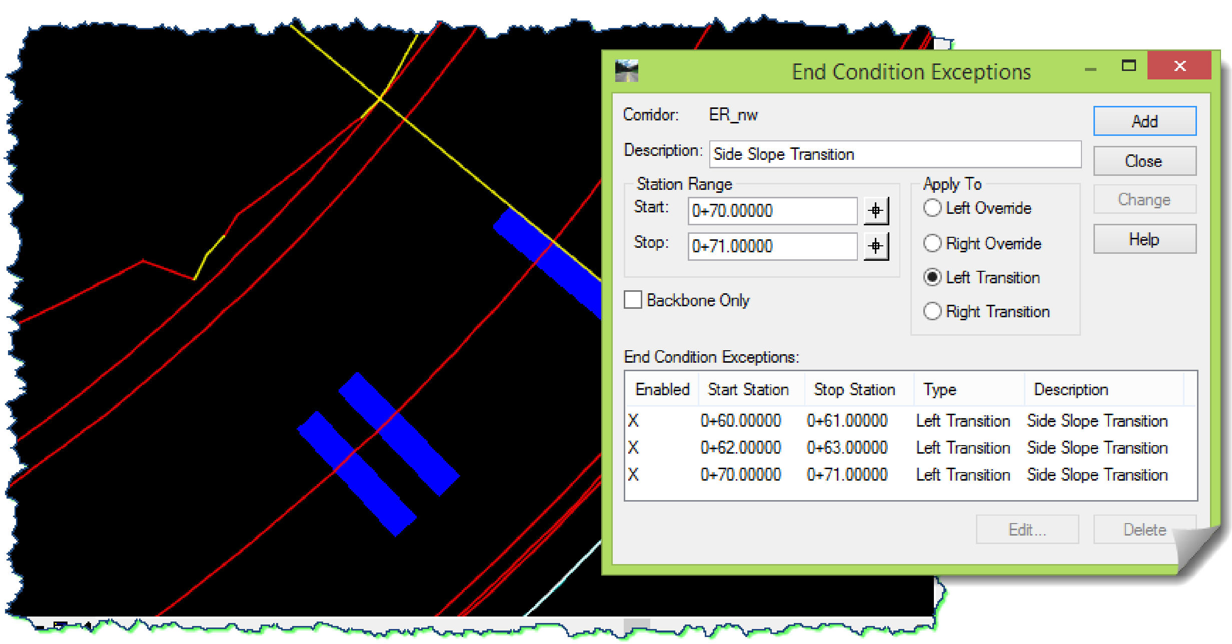
This is not specifically part of intersection modeling, and is being pointed out here just as a reminder to review your project model for any areas requiring additional work.

After setting up a corridor, you should [**Process All**], and then review the results in the plan and cross section views. In the case of the corridors created in this module, there are a few noticeable issues with the End Conditions that should be addressed.

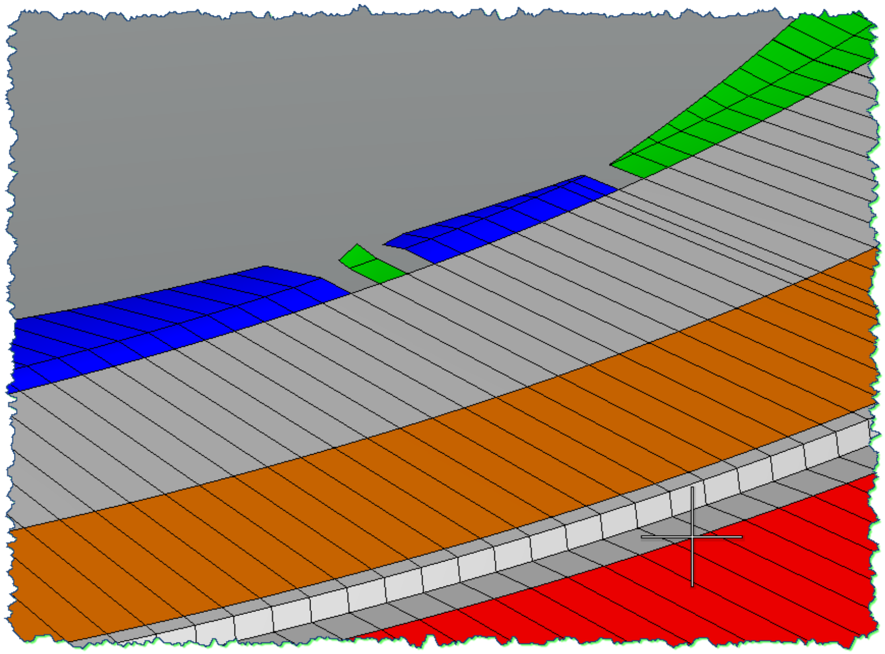
Reviewing the plan view in the **ROADWAY DESIGNER** reveals a few EC transitional issues.



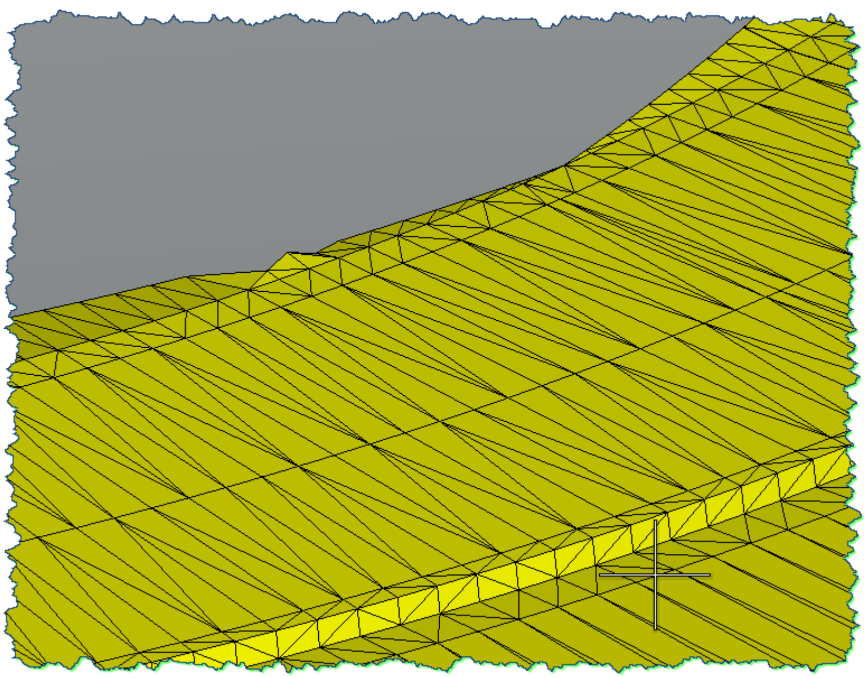
These can be addressed using the **END CONDITION EXCEPTIONS**.



If these areas are not addressed, the gaps will be visible whenever the components are viewed in MicroStation from the surface model.



Failure to address these will not cause any problems with the triangulation, only with the component construction.

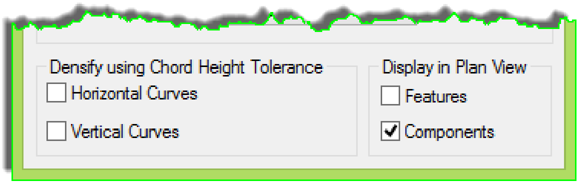


In some cases, these component transition failures are challenging to find and therefore are often addressed after the surface has been created by the **ROADWAY DESIGNER** and the MicroStation display and review is done. Addressing these areas only requires revisiting that corridor in the Roadway Designer and adding the **END CONDITION EXCEPTIONS** at the appropriate stations and then following through with the required transition editing.

Creating Design Model - North

All of these corridors should fit together like pieces of a puzzle since all of the 'join' locations were woven together by **POINT CONTROLS**.

When this composite model is created, the **ROADWAY DESIGNER** tool to **Create Surface** has a few options in the lower right to display the **Features** or **Components** in the **Plan View**.



We will do this, but for clarity, this information will be displayed in a new MicroStation model, not the DGN model that we've been working in up until this point.

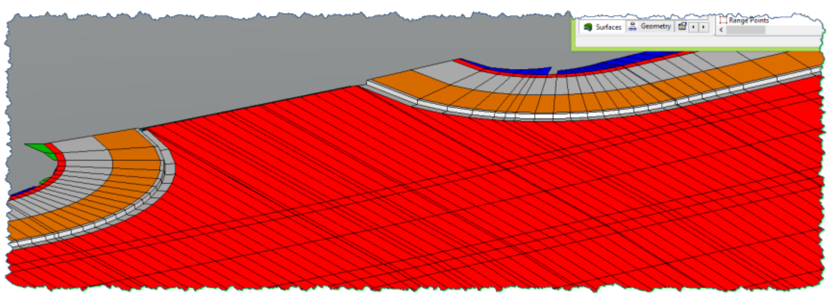
1) Create a new MicroStation model for viewing the upcoming components to be created.

The new model should be the active model at this point.

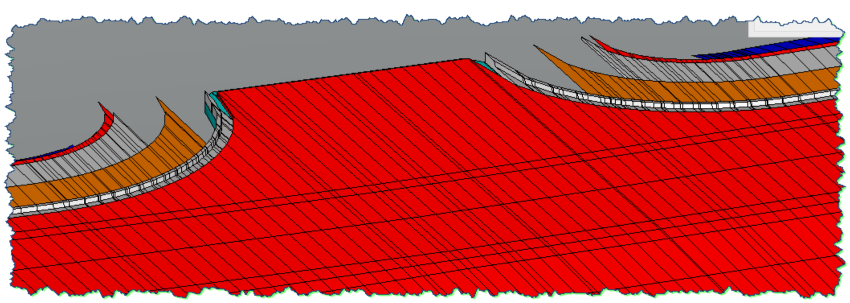
Viewing Components

The display of **Components** in a surface can be done from the **VIEW COMPONENTS** tool, but there is also an option to view **Components** under **Display in Plan View** on the **CREATE SURFACE** dialog box.

Currently there is a difference in the display of components using this toggle option during surface creation and the **VIEW COMPONENTS** tool under the **SURFACE** commands, resulting in variations between the displays. One significant difference is that the **VIEW COMPONENTS** tool does not account **for Secondary Alignments** or **KEY STATIONS** that may have been used to produce that model. Beyond that, other component display oddities can occur as shown below.



Component Display from the Create Surface tool



Component Display from the View Components Command

For this reason, moving forward, the components will be displayed from the **ROADWAY DESIGNER** at the same time that the surfaces are created. Note that you are not required to view components to check or validate your surface, but as discussed in Module 2, *Visualization*, there are some benefits in doing this.

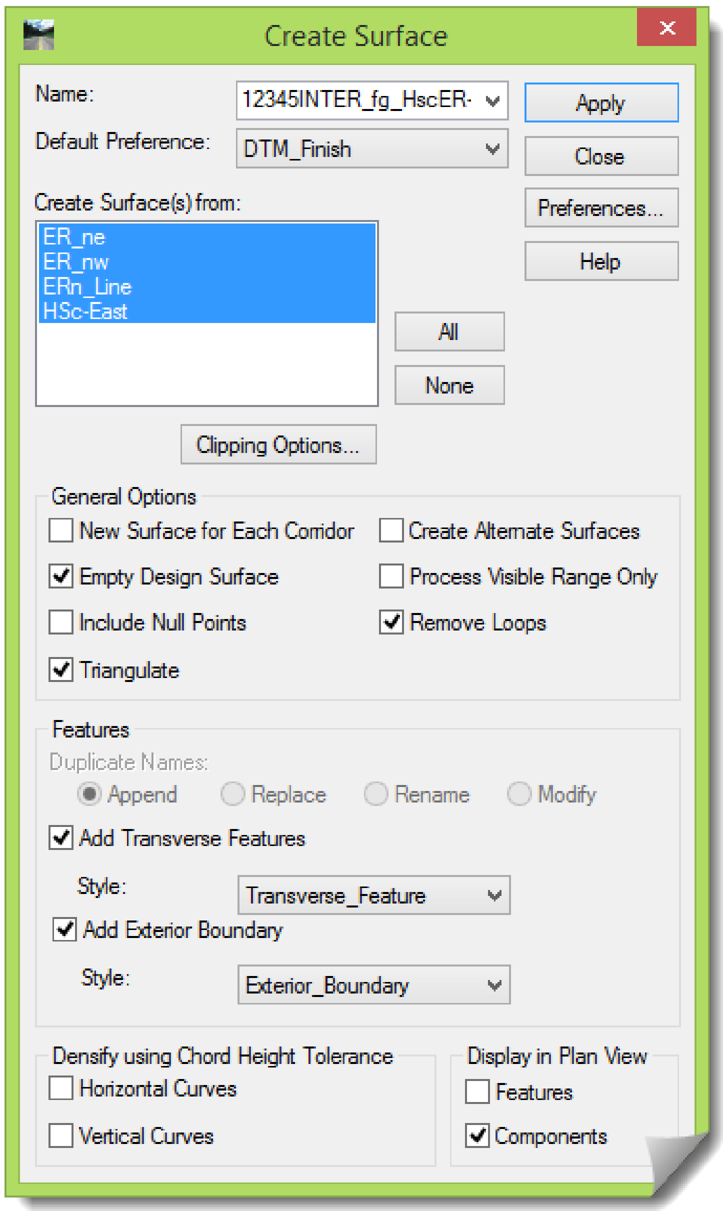
Creating the Composite Model

1) Go to **Create Surface** on the **Roadway Designer** dialog box.
2) Establish the settings on the dialog box as shown here and then create the surface called **`12345INTER_fg_HscER-S1`**.

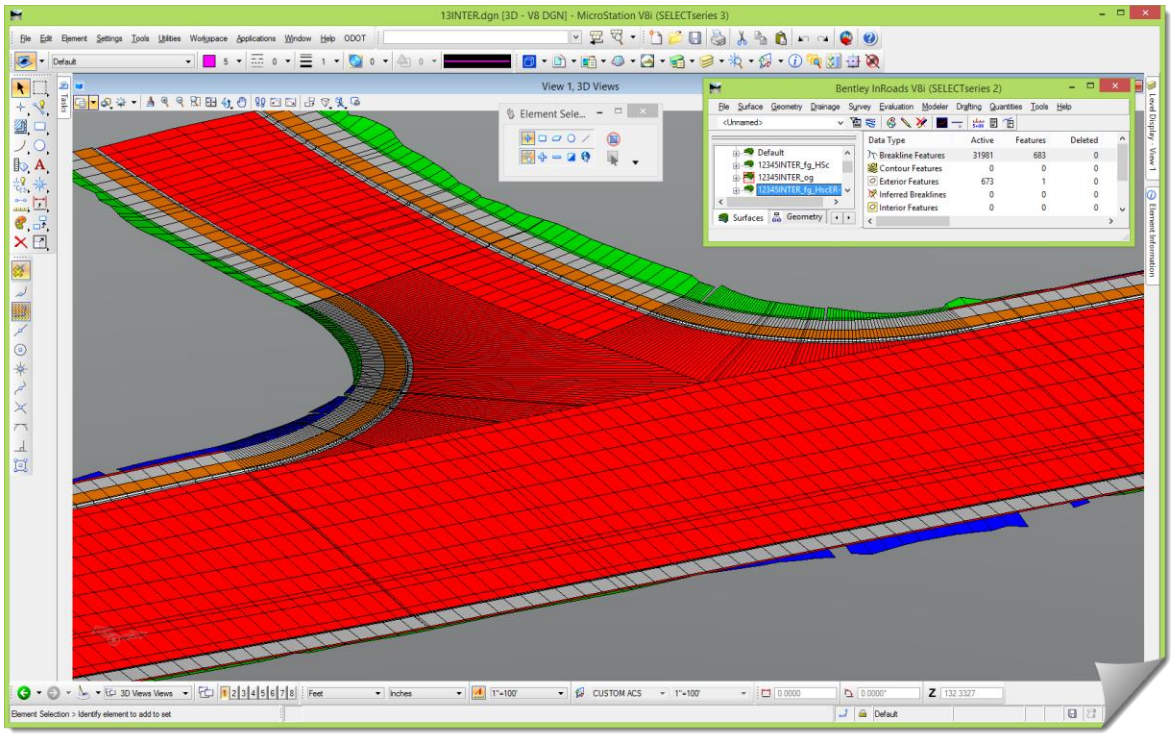
If any settings shown here are unclear, make sure you look at the *Help* file or review earlier material to ensure that you understand why certain settings are either *on* or *off*.

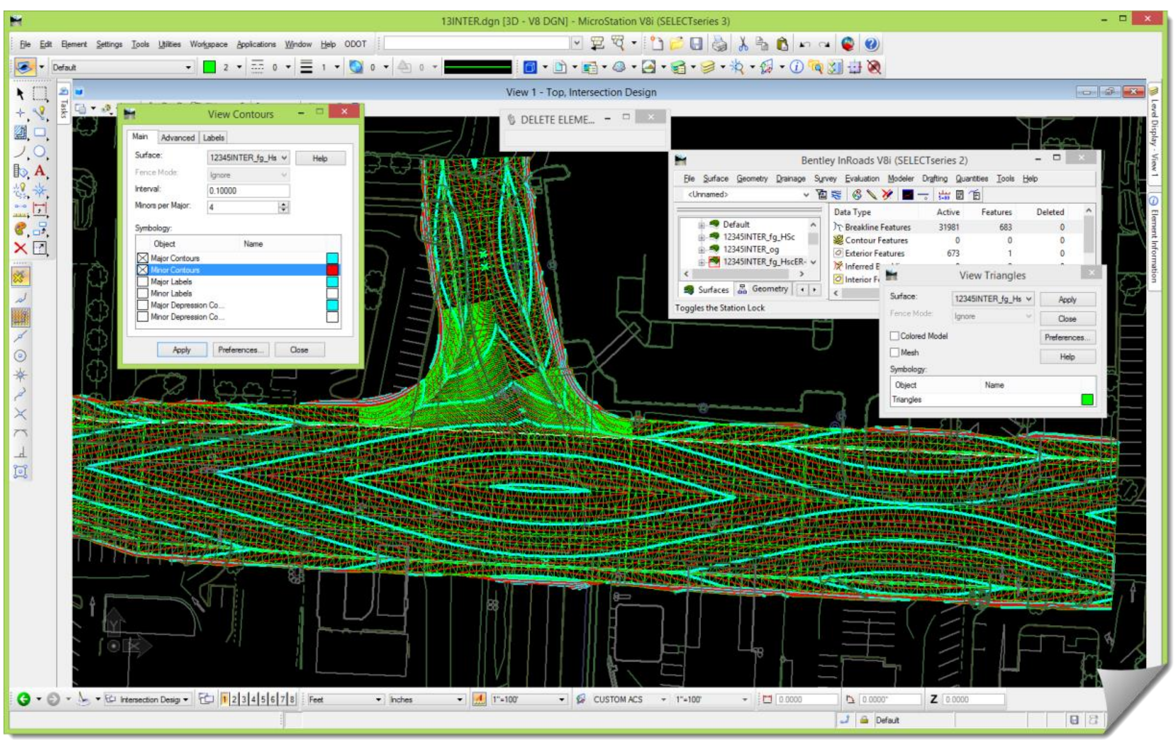
Other commentary:

- Toggles such as **Add Transverse Features** may or may not be applied on your project based on your intended results.
- **Densify Using Chord Height Tolerance** will also potentially be toggled *on*.
- As mentioned earlier, we will be toggling *on* **Components** in the **Display in Plan View** section.



3) View and display your resulting surface as needed by:
    a. Viewing / displaying **COMPONENTS** / **TRIANGLES** / **CONTOURS** in plan view
    b. Display 3D views
    c. Review drainage with **TRICKLE** tool
4) [**Save**] the design Surface.



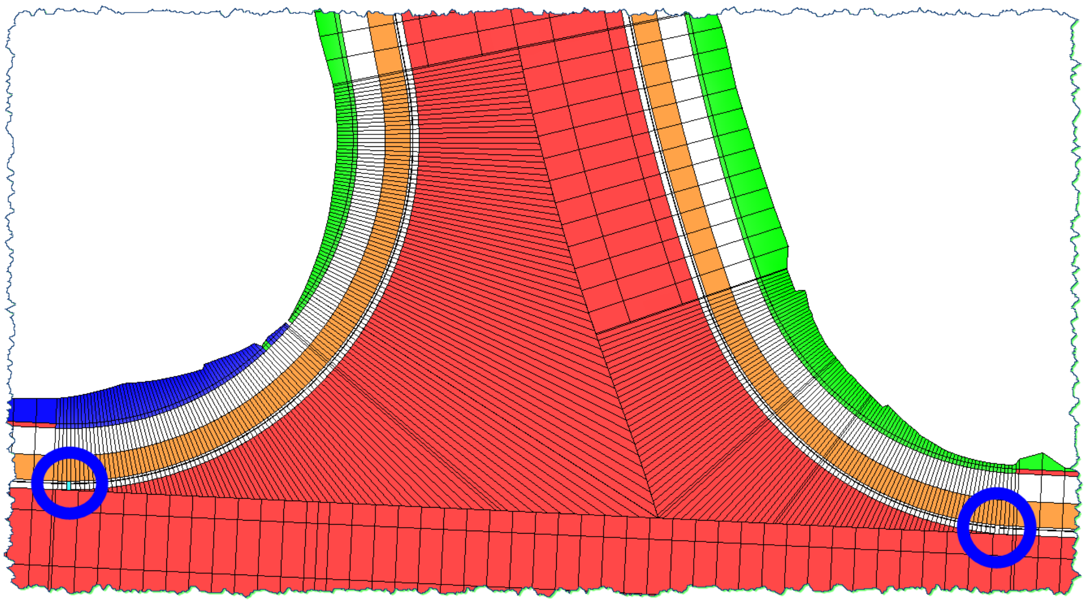


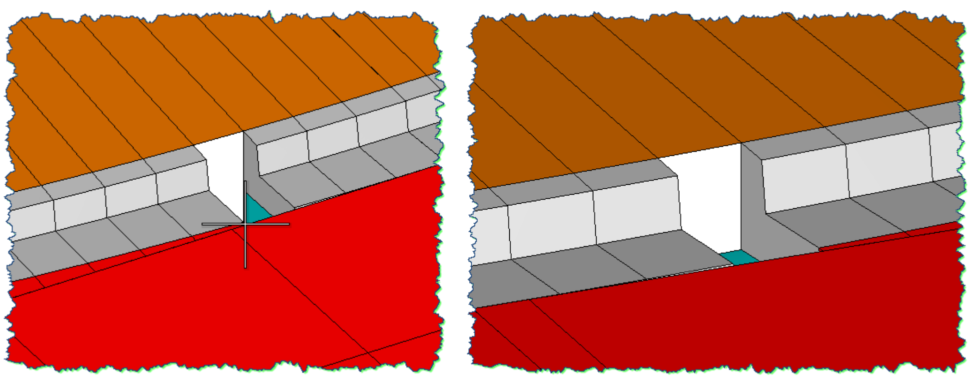
If you review the model closely, you may find areas that require some attention.

In this model, one particular item will be addressed; missing curb components.

TIP: Missing components from a corridor model surface do not necessary have to be fixed. Of more importance is that the breaklines have been properly created, and the surface triangulation looks correct. Failure to form components is not uncommon, and can be due to several factors including breakline naming continuity and component naming continuity. Components are required for visualization, display on cross sections, and quantities. If these areas are important, then some extra time will be needed to ensure that the components are being created adequately.

The two areas to be addressed are on the returns as they converge with the primary roadway.





The problem is the curb component has not formed in those two areas; the triangulation is actually fine in this model in these areas.

This will be addressed by adding a few **Key Stations** to force additional modeling to occur in those areas. In some case, the only 'science' to knowing where to add the **Key Stations** is 'trial and error'. This isn't a problem since it is easy to add and remove these additional modeling drops.

5) Go to the **Roadway Designer** and set the **Corridor** to **ER_nw**.

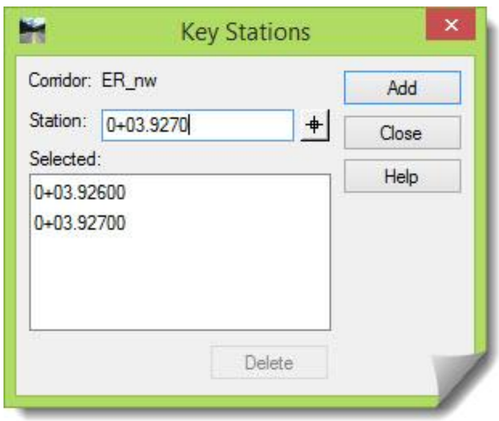
6) Before moving to the next step, feel free to determine the best **Key Station** to add to the return corridors that will result in the curb component being constructed. The process will consist of adding a **Key Station**, creating a new model, and viewing the results. Based on the results, add an additional **Key Station** and check the results. The entire process is an iteration of adding and removing **Key Stations** and determining which ones are needed.

Unfortunately, the **Roadway Designer** does not show these missing components in its Cross Section view, or any view for that matter. The only way to validate that the component will be created is to view the components in the MicroStation view while creating the surface.

To narrow down where to start applying a **Key Station**, start with stations that are at the up-station portion of the missing component. More often than not, missing component creation is caused by a failure to have a modeled section at a station just before a successfully created component.

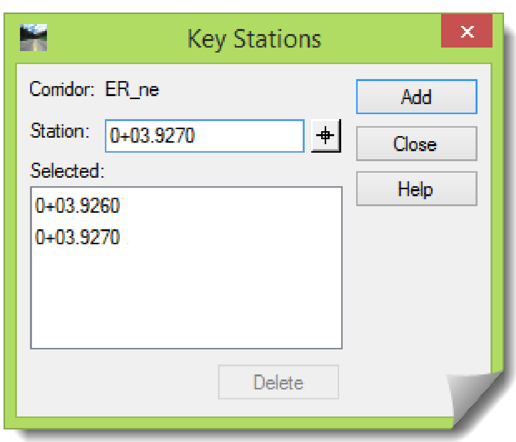
7) Enter two new **Key Stations** to the **ER_nw** corridor:

- Station **0+03.9260**
- Station **0+03.9270**

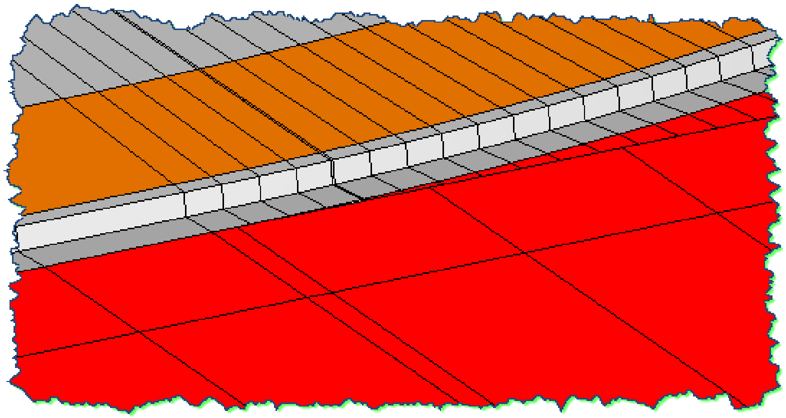


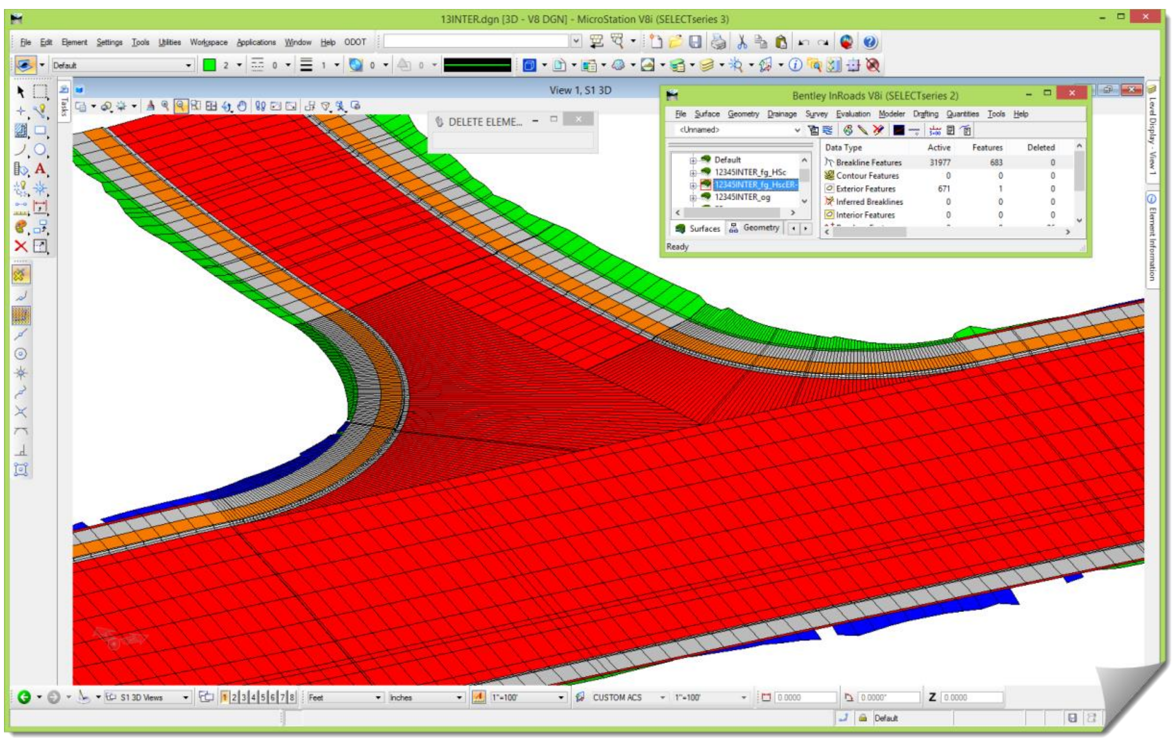
8) Now add these same **Key Stations** to the **ER_ne** corridor.

Luckily in this case, the same **Key Stations** work for both since the stationing is the same, the returns were created the same way, and they are both modeled identically.



9) After the **Key Stations** have been finalized, create a new design surface for scenario 1 and review the results.




13INTER.dgn [3D - V8 DGN] - MicroStation V8i (SELECTseries 3)
File Edit Element Settings Tools Utilities Workspace Applications Window Help ODOT
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Bentley InRoads V8i (SELECTseries 2)
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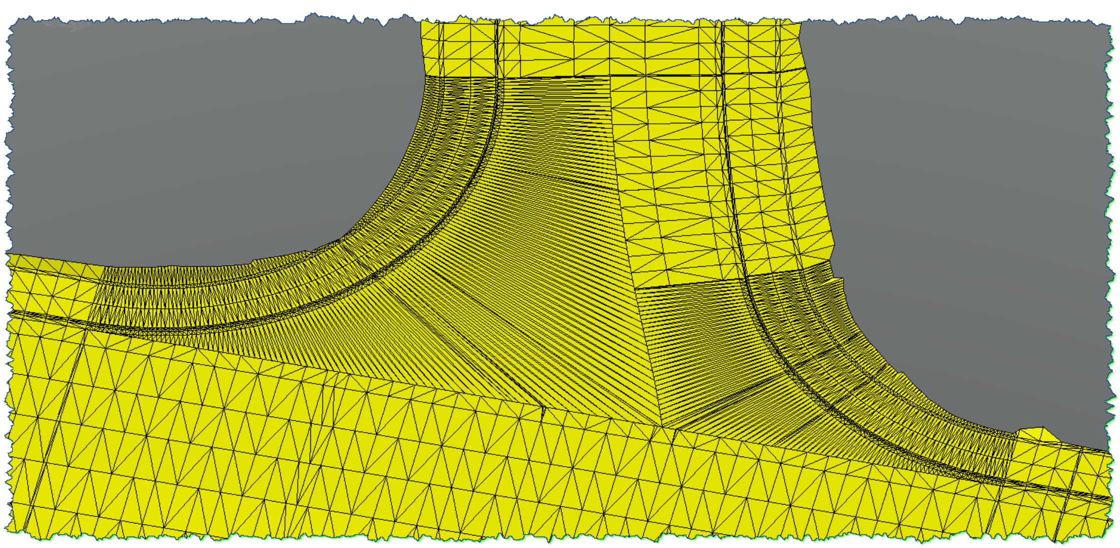
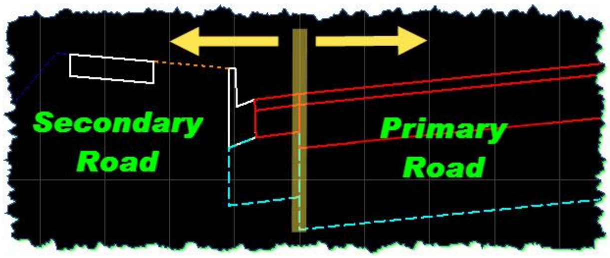
Surfaces
Geometry
Ready



Structural Pavement Section Transitioning

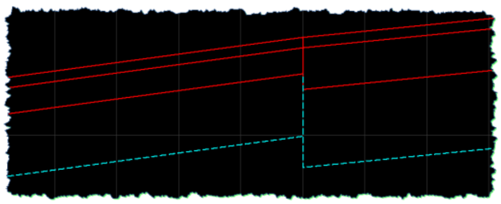
The final area that will be looked at on this particular intersection is the structural pavement section, and specifically the aggregate base course. Currently the full primary road structural section is directly adjacent to the full secondary road structural section like this:



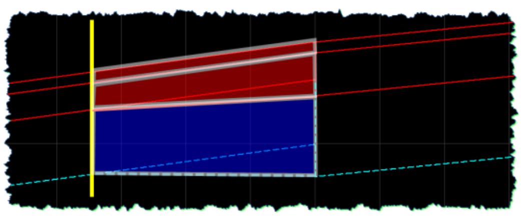
When two structural sections meet like this, a decision has to be made as to how they will join.

A few options are:

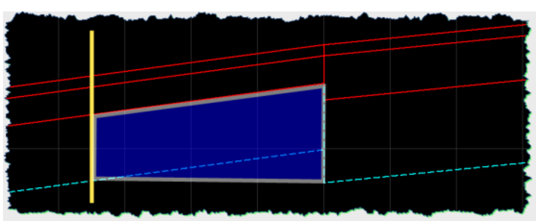
a. Leave all layers in the adjoining sections at their original design depths



b. Develop some sort of transition from one section (usually the thinner one) to gradually (over some defined distance) meet the thickness of the adjoining section as it approaches it



c. Leave some layers static and unchanging, while developing the transitional depth on only certain layers



The decision regarding which of these options to use is dependent on the project requirements or standards put in place to address these conditions.

From a simplistic standpoint, various tools can be used to model these transitions, including:

- Using **Point Controls**
- Using **Parametric Constraints**
- Using **Template** transitioning
- Using additional **Components**

This module will show a technique to apply the third condition where only the aggregate base course will be transitioned. The overall depth of the secondary road will be transitioned to the overall depth of the primary road as shown in the picture under '**c**' above, without modifying the asphalt base or wearing course layers.

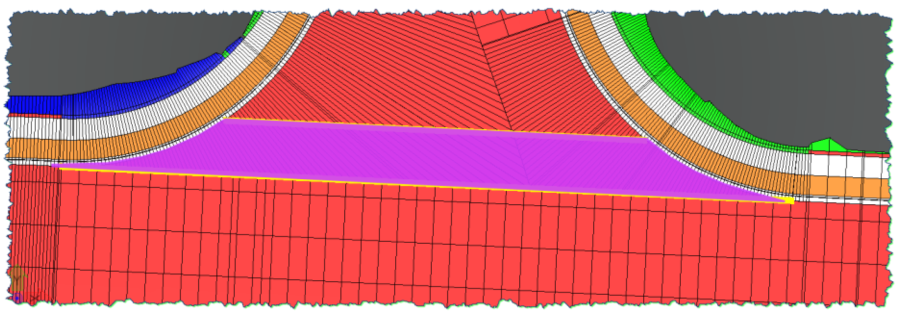
Once the transitional technique is defined, the next piece of information that is needed is the distance from where the transition will start. This is shown by the yellow line in the previous cross section pictures. That line establishes the horizontal control location.

The transitional distance and orientation of the transition is somewhat arbitrary. Many of the contractors using automated machine guidance want a continuous surface for grading. It can't have abrupt changes in grade, and when it does, some contractors are forced into rebuilding the models to eliminate that abrupt change.

As a guide, shooting for a minimum of **15**' for the transition (the approximate width of a blade used in urban and rural highway construction) is a good start. The distance can be shorter if it creates a crest, but actual dimensions will be site-specific.

Again, as a guide, lean toward an easier design method for the modeling, making sure that the design is not creating an abrupt break between the left and right sides of the road. In some cases, it might make it easier to design certain transitions perpendicular to the secondary road.

Moving forward, this module will use a **15**' offset from the **EP** of the primary road as the transition zone for the aggregate base course.



One of the biggest challenges to developing this transition is that the horizontal location, as well as the vertical 'angle point' where the transition starts, very often does not equate to any actual physical point in the corridor model. In addition to that, it might not harmonize with the way the corridor is actually modeled. These conditions require the development of either new geometry or a new surface feature to use as the horizontal and vertical control for the transition path.

Aggregate Base Course Transition

This will be the general workflow (the following hands-on section is optional):

a. Create a MicroStation line that represents the start of the transition on the secondary road. In this module, this line will be parallel to the primary road, offset **15**' from the **EP**, and extend from the **CurbBB-SG** on one side to the same feature on the other side.

b. Import the MicroStation graphic and drape it onto the design surface.

c. Lower the feature the depth of the secondary road structural section (in this case it's 19").

d. Collect any relevant control features from the design model and combine them into a control surface to be used later in the modeling of this area.

e. Run the aggregate base course 'filler wedge' along the primary road subgrade, tying it to the transitional 'zero match' line created in steps **a** thru **c**.

Creating the Zero Control

The back edge of the wedge modeling will be created in MicroStation.

1) Using whatever method is easiest for you in MicroStation, create a parallel line offset **15.00'** offset from the primary roadway **EP**.
2) Trim this line to the bottom of the aggregate base course of the secondary road edges (from **CurbBB-SG** on one side, to the **CurbBB-SG** on the other side).

This will be the outer back edge of the transition zone.

3) Import this into a control surface called **12345INTER_control.dtm** and drape it onto the **12345INTER_fg_HscER-S1**surface.
4) Lower it to the depth of the secondary road structural section (in this instance, **19**").

It's important that this back edge follow the subgrade, and the early steps will require some clean up under the curbs since the finish grade doesn't parallel the subgrade under the curb.

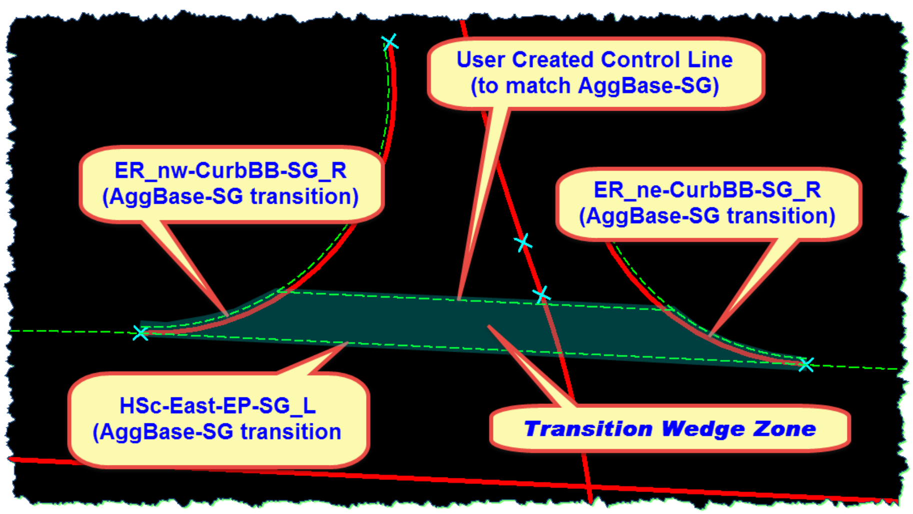
Here are few alternate suggestions for creating this back control edge:

a. If a subgrade **Alternate** surface is created, drape the edge line onto that surface
b. Create your own subgrade surface using the breaklines from the secondary road model
   - Copy them into a temporary surface
   - Toggle *off* the **Exclude from Triangulation** setting in **FEATURE PROPERTIES**
   - Triangulate the temporary surface
   - Use this temporary surface to drape the back control edge onto

Other Control Features

Other features will be used, but they already exist in the recently created design surface. They are:

- **HSc-East-EP-SG_L** – the bottom of aggregate base course on the primary road
- **ER_ne-CurbBB-SG_L** – the bottom of aggregate base course on the secondary road as it goes around the NE return
- **ER_nw-CurbBB-SG_R**– the bottom of aggregate base course on the secondary road as it goes around the NW return

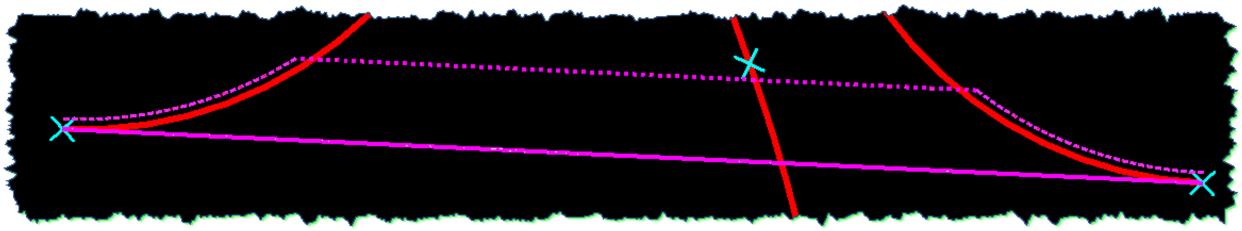


The main path for the transition wedge will be the primary road **EP-SG** since that is where the two structural sections meet, and this is an important control feature.

1) Using the **Copy Portion of a Surface** command, copy the three breakline controls listed earlier into the `12345INTER_control.dtm` and [**Save**] it.
2) Clean up the features in the control surface using the surface editing tools.

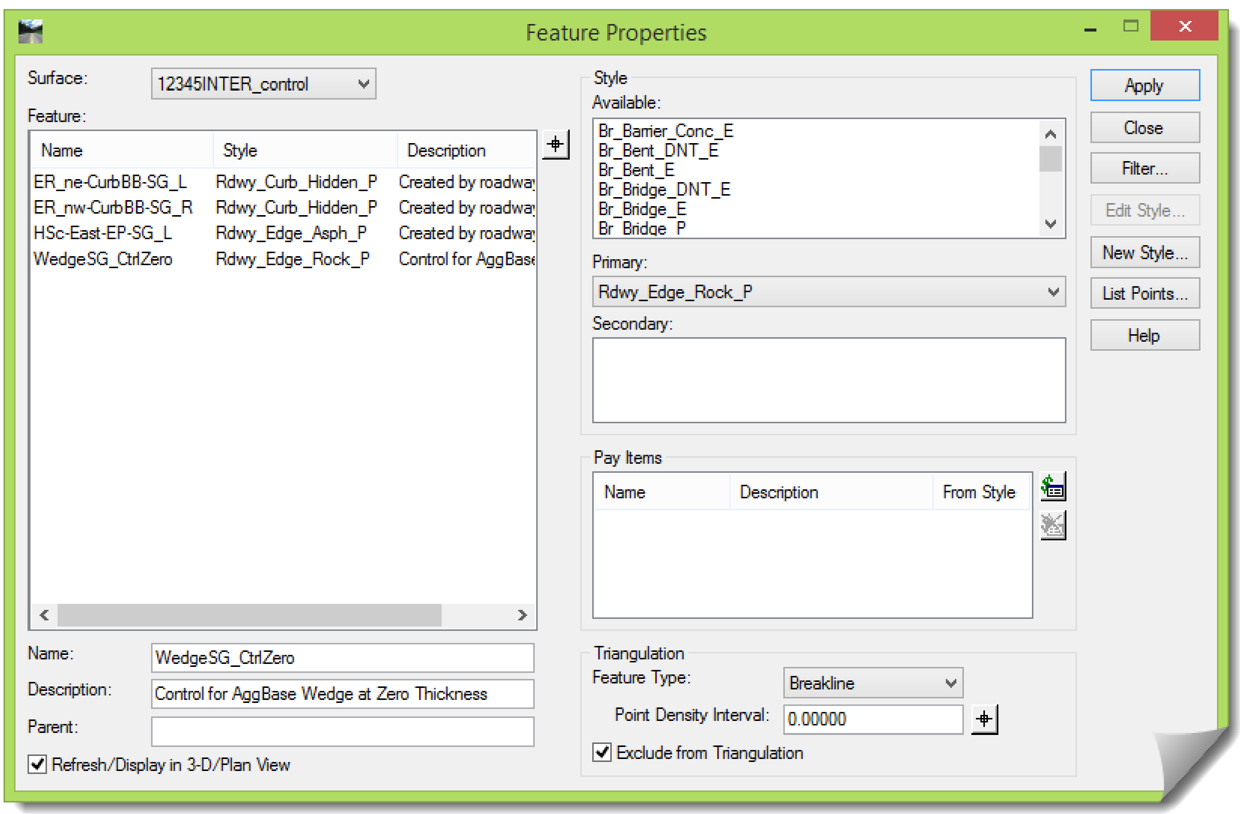
This would include trimming them so that they match horizontally and editing the points so that they tie into one another elevationally, as well as following the subgrade under the curb.

This will make the assignment of point controls easier later.



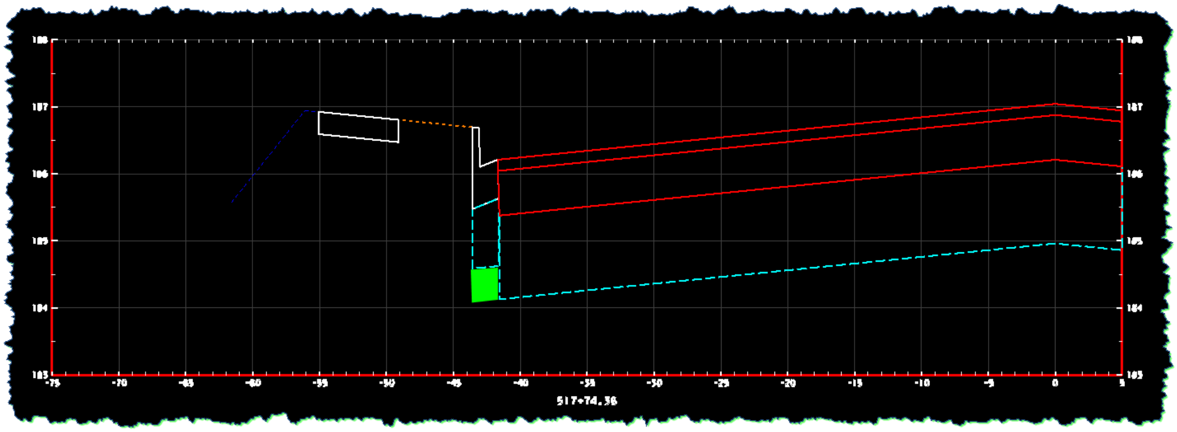
There should be four control features in the surface.

The purpose of each of these features will be discussed shortly.

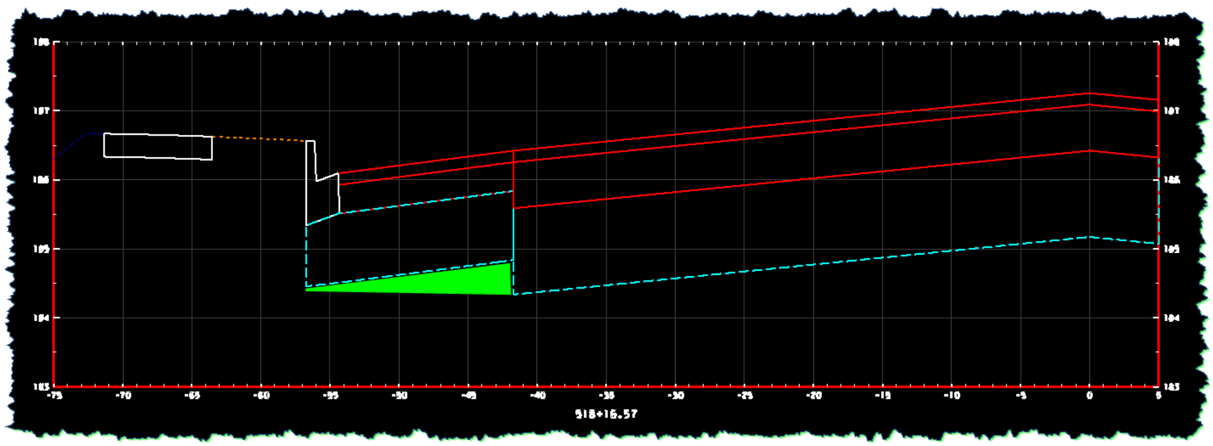


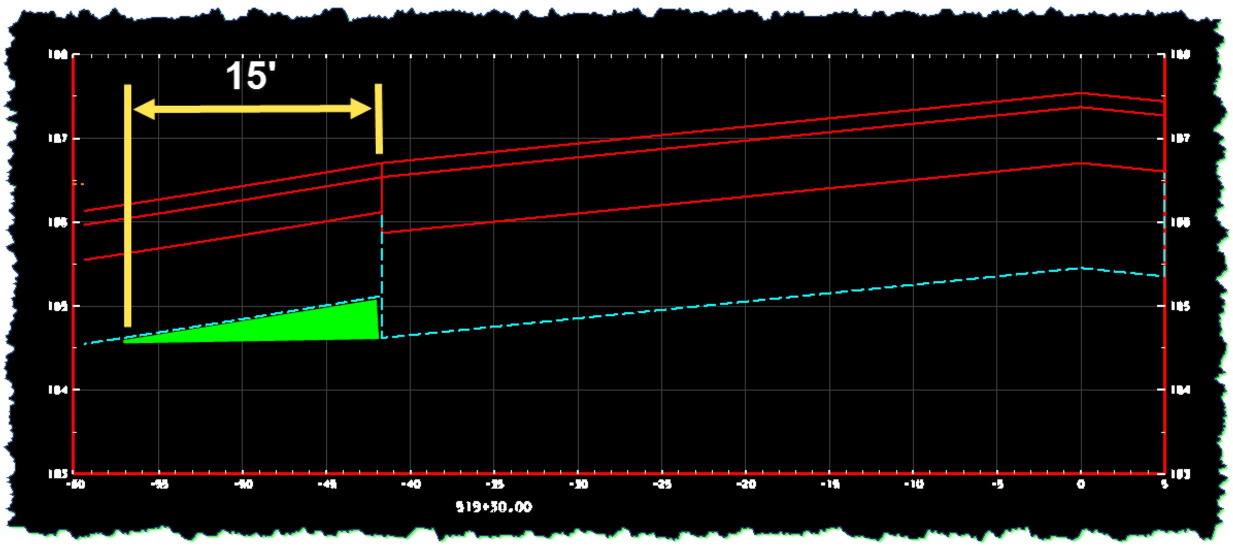
Developing the Aggregate Wedge

The sections at the start and end of the intersection currently look like this, with the shaded 'transition wedge' area to be modeled with the following process.



The sections for the 'match' location at, and between, the returns currently look like this, with the 15' transitional shaded area to be modeled with the following process.





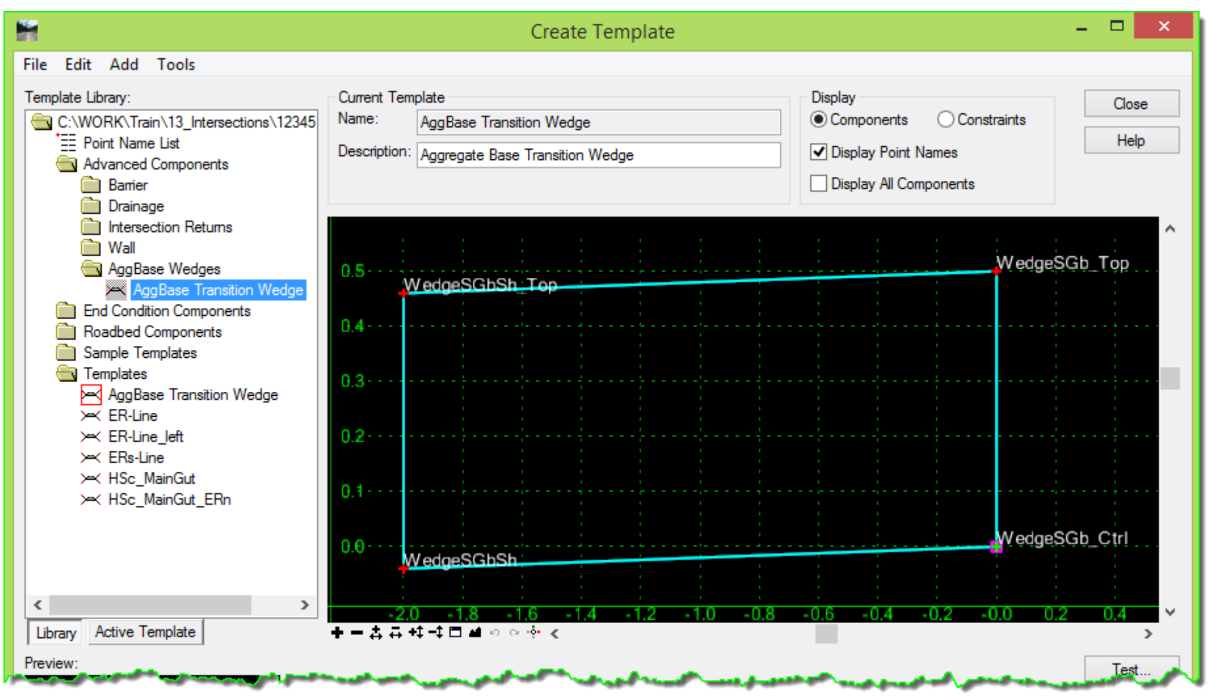
Building the Wedge Corridor

The wedge component has already been created, and is a very simple component.

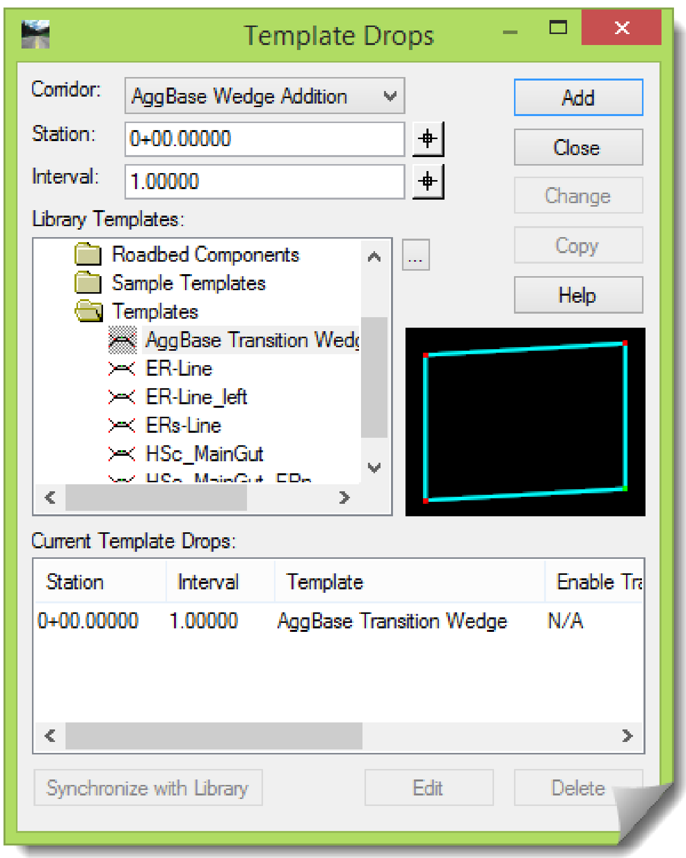
1) Open the **Create Template** tool and **Copy** the **`AggBase Transition Wedge`** component in the **AggBase Wedges** folder under the **Advanced Components**, placing the copy in the Templates folder for our use.
2) Do a review of this component, taking note of the point names and constraints.

Here are a few things to consider:

- Since the primary road section is 25" thick, and the secondary road is 19", the wedge height is making up for the difference of 6".
- **`WedgeSGb_Ctrl`** will be the point tied to the primary road **`EP-SG`**, acting as the **Corridor** path in the **Roadway Designer**.
- **`WedgeSGb_Top`** will fill in the AggBase gap between the bottom of the primary road aggregate and the bottom of the secondary road aggregate, along the primary road **`EP`**.
- **`WedgeSGbSh_Top`** will follow the secondary road bottom of AggBase around the returns across the secondary road as it travels along the 'zero control line' to the other return. This template point will be assigned three feature point controls:
  - Around the NW return away from the primary road
  - Along the 'zero back' control
  - Around the NE return toward the primary road
- **`WedgeSGbSh`** will follow below **`WedgeSGbSh_Top`** and transition the thickness around the NW return, maintain zero thickness along the control between the return, and then transition back to the necessary thickness as it travels along the NE return.
  - A **Parametric Constraint Label** called **`SGbShWedgeThickness`** will control the thickness transition from the required **6**" filler along the primary road **`EP`** to the zero thickness, **`15`**' from the primary road **`EP`**.

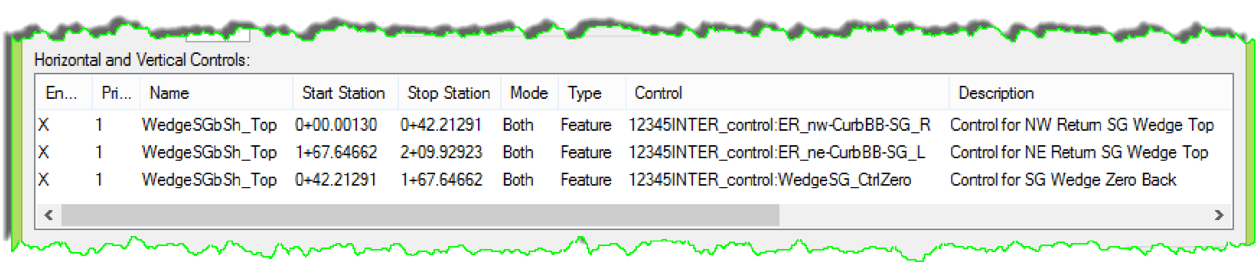


3) Go to the **ROADWAY DESIGNER** and create a new **Corridor** for this transitional wedge of aggregate base course with settings similar to these shown here:
   - **Name**: <u>`AggBase Wedge Addition`</u>
   - **Type**: **Feature**
   - **Surface**: `12345INTER_control`
   - **Feature**: `HSc-East-EP-SG_L`
   - **Station Limits** should be set appropriately to **Start** and **Stop** between the return extremities. If the feature `HSc-East-EP-SG_L` was trimmed between the PCs of the returns then the **Limits** can be toggled *off*.
4) Drop a single entry of the `AggBase Transition Wedge` template. (This will be used for the entire model.)



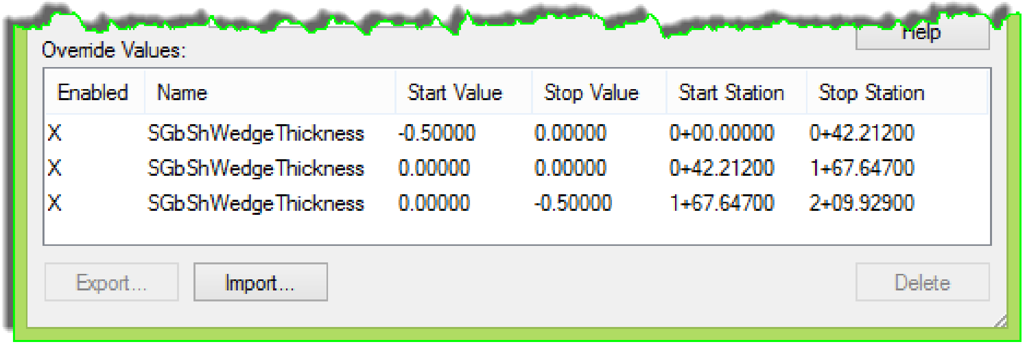
5) Assign the **POINT CONTROLS** as described earlier.

Remember to leave a slight **Offset** to ensure that duplicate breaklines are not created when this corridor is combined with the others. In this case, the 'slight' **Offset** would be **Vertical** (below).


Horizontal and Vertical Controls:

En...	Pri...	Name	Start Station	Stop Station	Mode	Type	Control	Description
X	1	WedgeSGbSh_Top	0+00.00130	0+42.21291	Both	Feature	12345INTER_control:ER_nw-CurbBB-SG_R	Control for NW Return SG Wedge Top
X	1	WedgeSGbSh_Top	1+67.64662	2+09.92923	Both	Feature	12345INTER_control:ER_ne-CurbBB-SG_L	Control for NE Return SG Wedge Top
X	1	WedgeSGbSh_Top	0+42.21291	1+67.64662	Both	Feature	12345INTER_control:WedgeSG_CtrlZero	Control for SG Wedge Zero Back

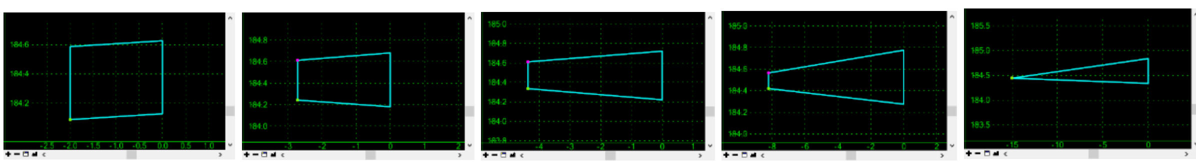
6) Using the **Label** called **`SGbShWedgeThickness`**, assign **Parametric Constraints** to transition the aggregate base course around the returns from the starting thickness of 6" to the ending thickness of 0", as well as along the back of the wedge at 0". Use the stationing from the **Point Control** entries as a guide.



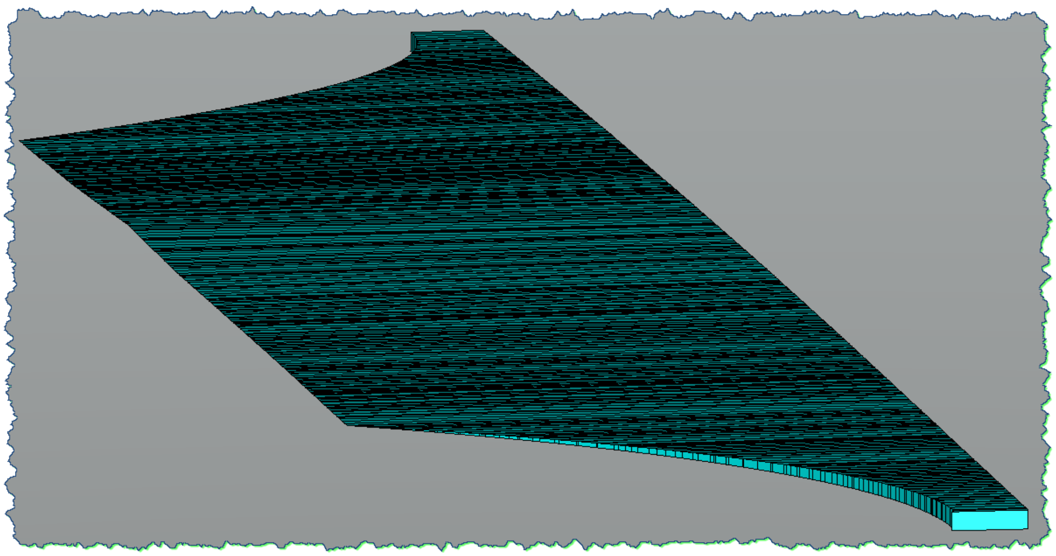
Enabled	Name	Start Value	Stop Value	Start Station	Stop Station
X	SGbShWedgeThickness	-0.50000	0.00000	0+00.00000	0+42.21200
X	SGbShWedgeThickness	0.00000	0.00000	0+42.21200	1+67.64700
X	SGbShWedgeThickness	0.00000	-0.50000	1+67.64700	2+09.92900

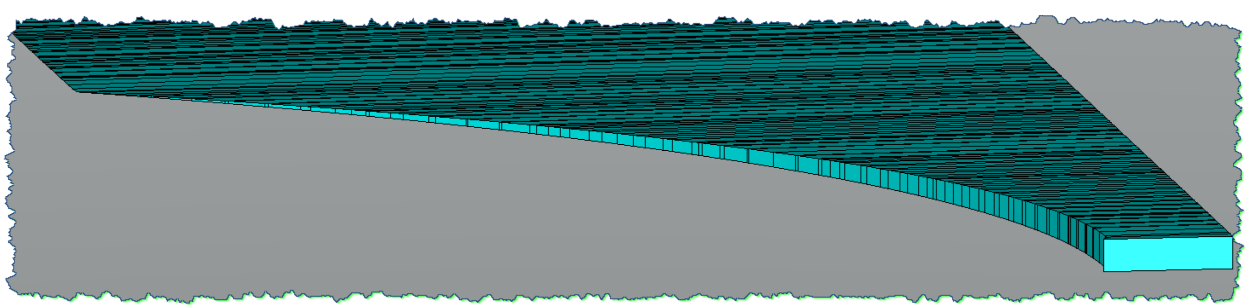
7) Review the model cross sections.

You should see the transitioning of the wedge component as it moves around the return, across the back and back toward the primary road.



8) Create a surface with only that corridor and review the resulting component wedge.

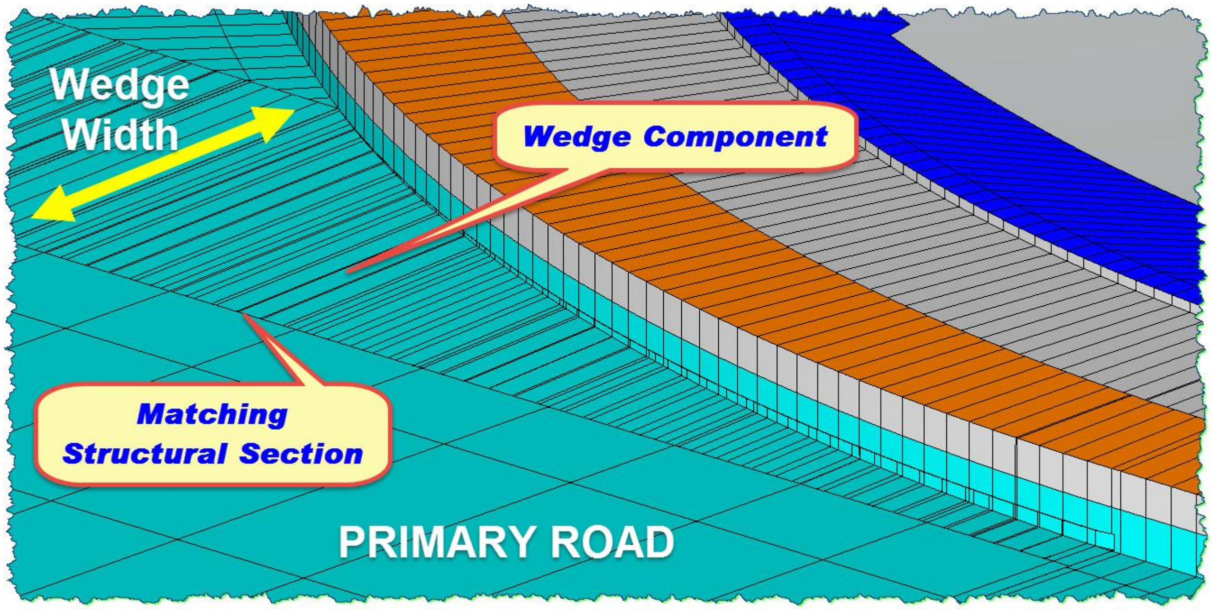


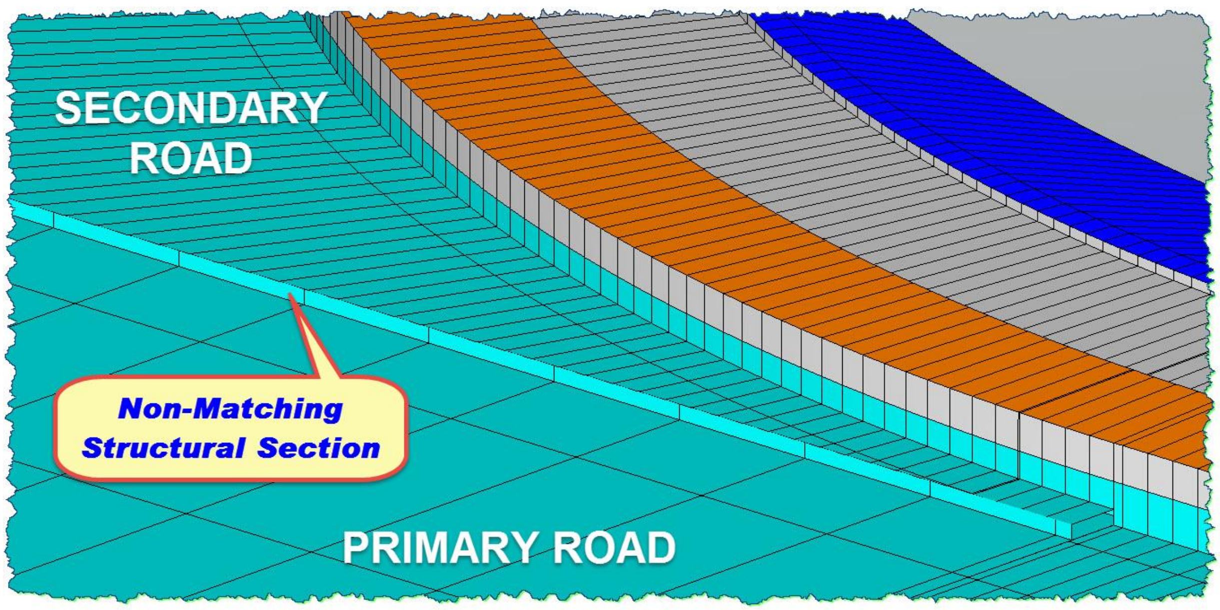


9) Create a surface with all of the corridors and review the resulting components.

The wedge component is underneath the secondary road so you will have to use your 3D rotation and viewing skills from Module 2 to see this. If you recall the underside of the intersection before the wedge was created, you should see the difference.

These are underside shots with and without the wedge components.





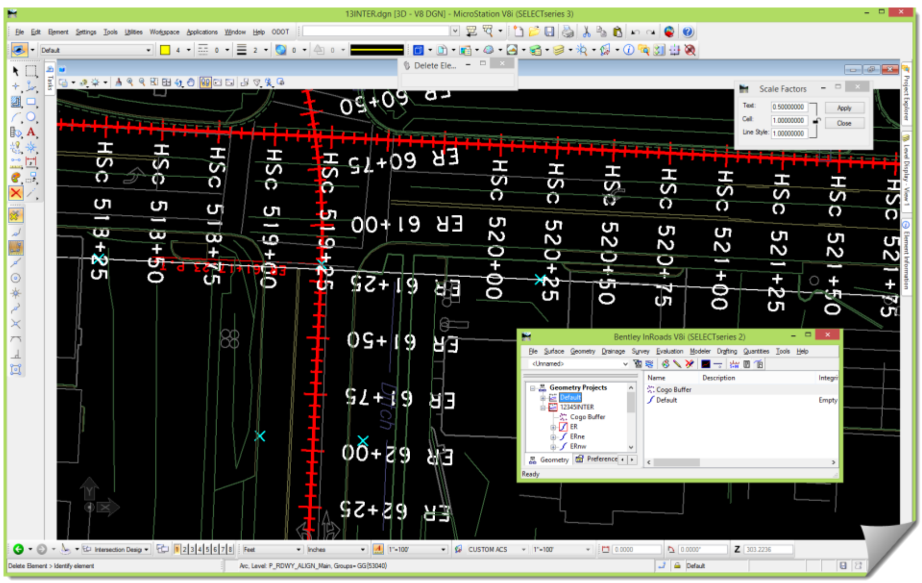
At this stage, the modeling has produced all of the features necessary to create a surface model for the aggregate base course. Understand that the transition modeled here is unique and has to be treated as an 'add-on' to the typical corridor modeling. Now, in order to create a surface model of this area, some manual copying of features will likely have to be done since there are conflicts with the bottom features of the secondary road. Other transitional modeling techniques won't have this liability, so be aware of it. Each transitional area can have its own unique controls and techniques that can eventually result in the feature data that you need to create these surfaces.

SCENARIO 2 - SOUTH INTERSECTION

The modeling that will be done next will be the south side of the secondary road. The southerly intersection will be modeled using a different method than the northerly portion. This will introduce another way that intersections can be modeled. There are a few differences with this intersection:

- The secondary road is perpendicular to the primary road
- There is an existing ditch on the east side (the SE quadrant) that will be tied into
- This will be modeled showing a different methodology than **Scenario 1**

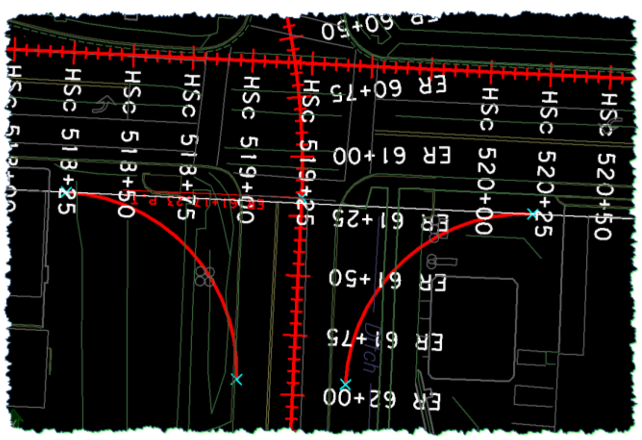
We're starting with the primary corridor (**`HSc-East`**) from the last scenario (which now includes the revisions to incorporate the northerly intersection), as well as all of the earlier geometry.



Adding Curve Returns

1) As done in **Scenario 1**, use the **MULTICENTER CURVE** tool to construct the horizontal and vertical alignments for the returns on either side of the southerly intersection.
   - Radius 1 = **<u>`76.404'`</u>** (**`75'`** radius to the top face of curb, **`CurbTF`**, plus **`1.404'`**)

As a challenge, don't look ahead to the next pages. First, calculate your own return information required for the **MULTICENTER CURVE** command, and then compare it to what is shown later.



Here is the information that was used:

- **Name**: <u>`ERsw`</u>, `Scenario 2 - SW Return`
  - **Width 1** = <u>`58.693`</u> (at Station 518+50 along the primary road)
  - **Width 2** = <u>`23.693`</u> (measured from the **`ERs-Line`** template **`EP_R`**)
  - **Radius** = <u>`76.404'`</u> (arbitrarily selected here for technique illustration only)
  - **Gradient** based on slope = **-2.00%** (for both)
- **Name**: <u>`ERse`</u>, `Scenario 2 - SE Return`
  - **Width 1** = <u>`58.693`</u> (at Station 520+00 along the primary road)
  - **Width 2** = <u>`23.693`</u> (measured from the **`ERs-Line`** template **`EP_L`**)
  - **Radius** = <u>`76.404'`</u> (arbitrarily selected here for technique illustration only)
  - **Gradient** based on slope = **-2.00%** (for both)

Of course, the values above on your job will reflect <u>your</u> project-based design criteria.

Also, as a standard procedure, verify the alignment both horizontally and vertically, making any modifications as needed based on your project design criteria, drainage patterns and so on.

ALERT: The radius in the Multicenter curve tool is dependent on the chosen design radius at the top face of curb and the features you are matching into at the ends of the return.

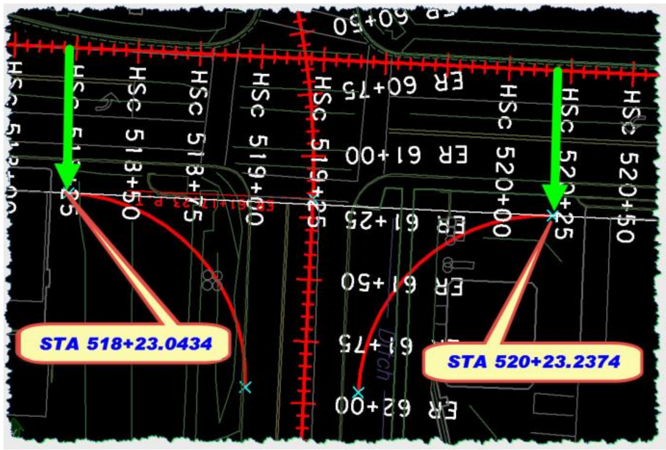
Primary Model Modifications

The primary road model will be modified to eliminate the curb & gutter, planter, sidewalk and ECs from modeling through the southerly intersection.

1) Based on the new returns, define the primary road stationing for the start and end of the new template that will run through the intersection.

Make sure that you've been able to obtain these results:

- Southwesterly return PC = **`518+23.04342`**
- Southeasterly return PC = **`520+23.2374`**



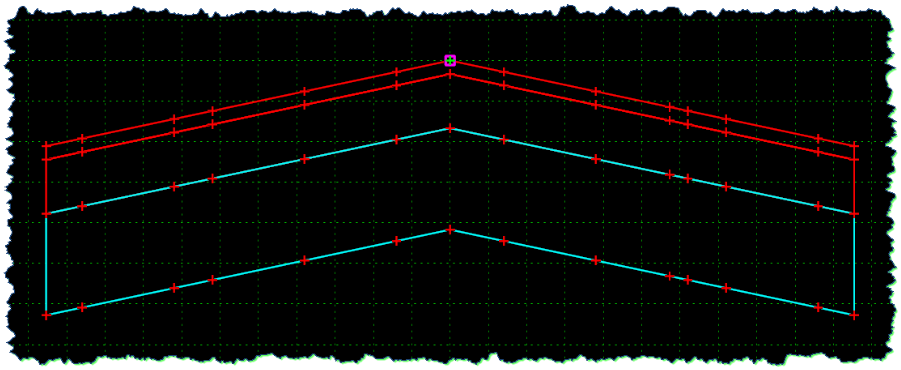
These station values will be used to remove the ECs, curb and gutter, planter, and sidewalk from the primary roadway. This will be done directly in the **ROADWAY DESIGNER** (IRD), a little bit differently than the previous scenario ITL work. This is discussed further in the last section of this module, *Other Details*.

2) Copy and modify template drops and templates on the primary road to remove any components beyond the **EP**, as was done in Scenario 1. These should not be running through the intersection with the secondary road. The basic steps are described here:

   a. Go into the **ROADWAY DESIGNER** tool and **TEMPLATE DROPS**. The templates will be copied and then edited directly in the IRD versus the ITL.

   a. Copy the template just prior to the stationing of the PC of the southwest curve (**HSc-Line**), placing it at the exact PC Station (Sta. **518+23.0434**).

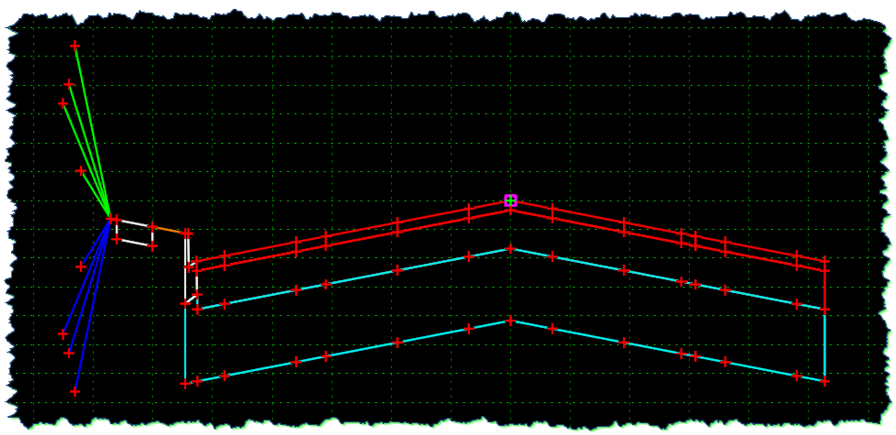
   b. Edit that template in the IRD to remove the components behind **EP_R** that should not be modeled through the intersection (select entry in the **Current Template Drops** list and choose **Edit** at the bottom).



   c. In Scenario 1, a template was placed at Sta. **519+84.2859** while running the backbone through the northerly intersection. This template has to be edited with the same removals from the **EP** outward. When this edit is completed, it will look exactly like the section above.

Close attention has to be made to this template editing when the primary road has different overlapping intersection locations on either side of the roadway. Just keep the stationing in mind, and always have a solid idea regarding what the section should look like before you do any editing.

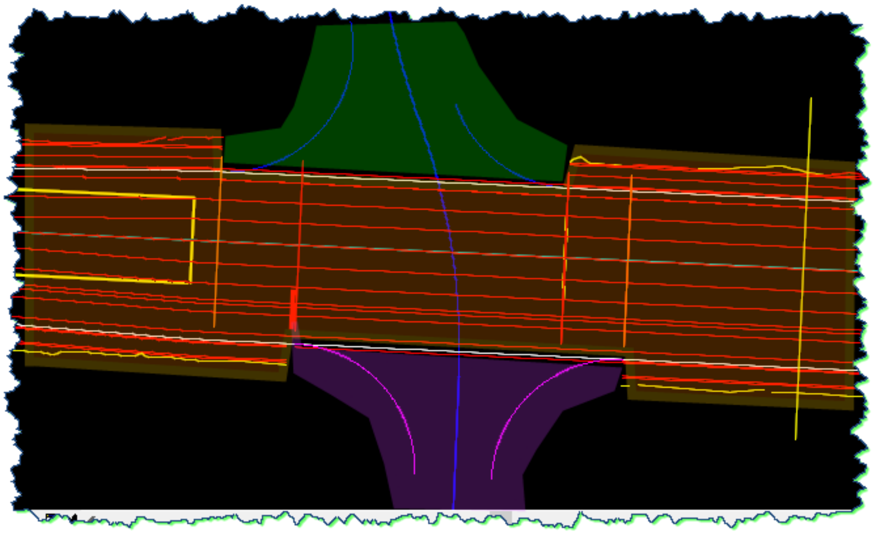
   d. In the case of the next section, there is a section prior to it (Sta. **519+84.2861**) that must also be edited on the south side, removing everything from the **EP** outward.



   e. Copy the template that defines the section related with the station of the PC of the southeast curve, placing it at the exact PC Station (Sta. **520+23.2374**) and make the same edits. (Or just copy a similar template drop and place it where needed.)

   f. Copy the full section template to the PC**+0.001'** (Sta. **520+23.2384**). This section will be continued onward from that location.

g. The goal is to have the primary road templates and drops modified to create a clean model through the intersection starting at the PC of the southwest return and ending at the PC of the southeast return further down station. This should be the case for both the northerly and southerly intersecting roads.



To wrap-up this **Corridor**, a **Key Station** has to be added to create a modeled section just prior to the template change at the southeast return.

3) Create a **Key Station** at Station **518+23.043**.

Secondary Roadway Modeling

Because of the direction of the secondary road, this model will start at the primary road **EP_R** and model southerly past the returns toward the end of the alignment.

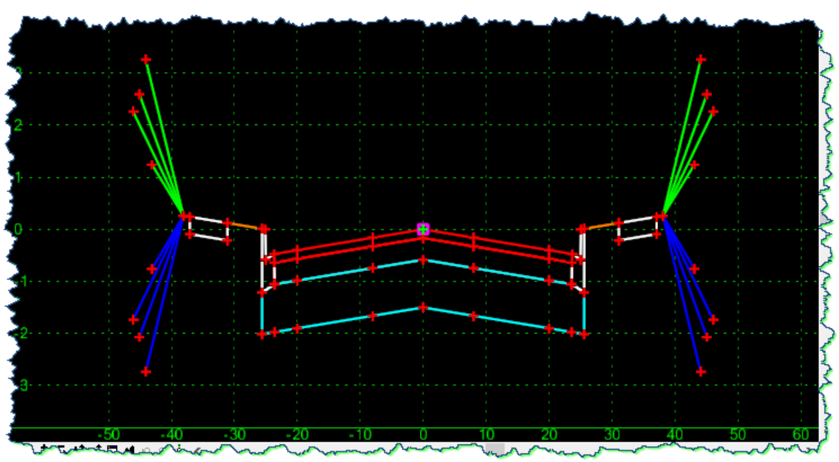
1) Determine the exact station of the start of the southerly secondary road model.

This would be the point where the **ER** alignment crosses the **EP_R** of the primary road.

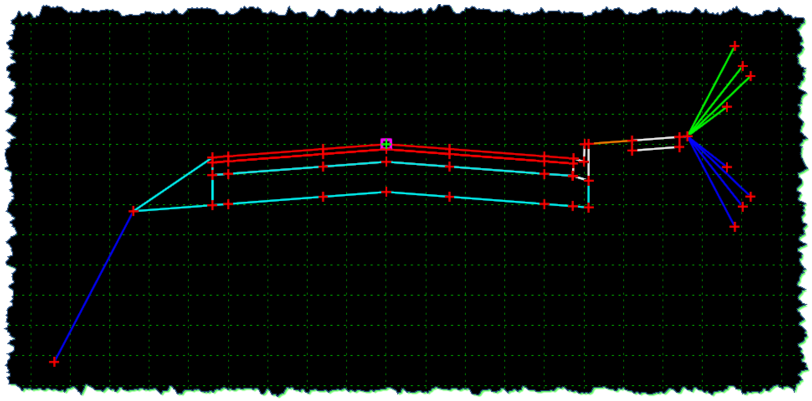
Using InRoads tracking, that station is determined to be **61+19.576**, and since we are only focusing on the intersection, this model will end at **62+50.000**.

2) Go to the **Create Template** command and review the two templates that will be used for this modeling:

- **ER-Line** – used from the start until the end of the returns



- **`ERs-Line`** – used from the end of the returns until 62+50 (the end of this model)



3) Create the **Corridor** for the secondary road.
   a. **MANAGE CORRIDORS**
      - <u>**`ERs_Line`**</u>
      - <u>**`61+19.576`**</u> to <u>**`62+50.0000`**</u>
   b. **TEMPLATE DROPS**
      - **`ER-Line`** @ **Station** <u>**`61+19.576`**</u>, **Interval** = <u>**`1.00`**</u>
      - **`ERs-Line`** @ **Station** <u>**`61+95.9797`**</u> (the end of the returns), **Interval** = <u>**`2.00`**</u>

In this scenario, the returns will be built directly into the secondary road model as point controls and modeled as an extension of that corridor.

4) Add two **Horizontal** and **Vertical** **POINT CONTROLS** to the secondary road for the returns that tie the two roads together.

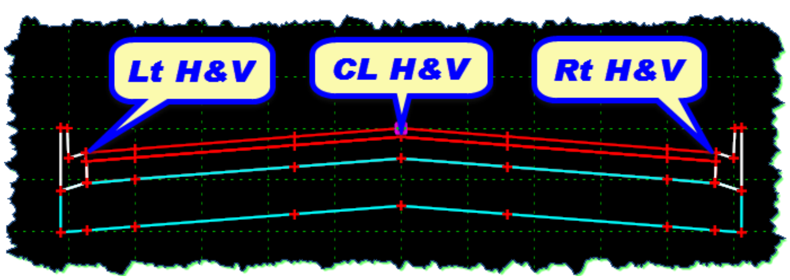
Because of the direction of the alignment, the returns will be modeled from their connection with the primary road, down station along the secondary road.

   a. Add horizontal and vertical point controls for the southwesterly return
   b. Add horizontal and vertical point controls for the southeasterly return
   c. Make sure you are using the **Secondary Alignment** option

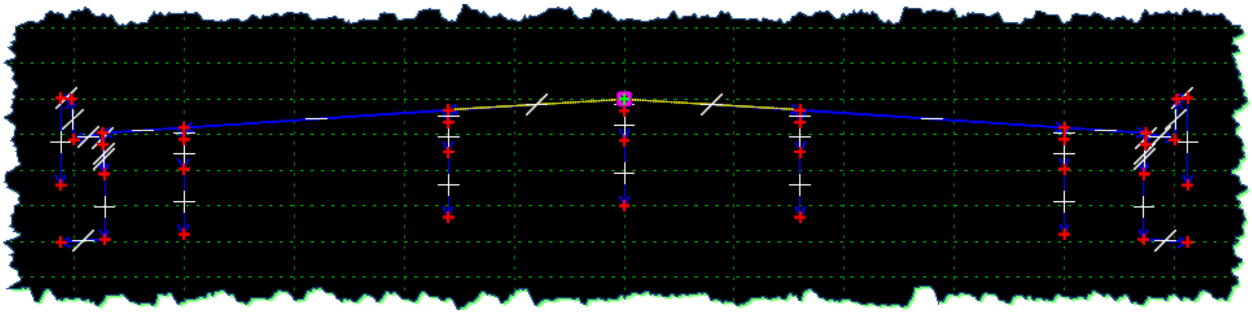
Horizontal and Vertical Controls:

Enabled	Priority	Name	Start Station	Stop Station	Mode	Type	Control	Description
X	1	EP_L	ER 61+19.57601	ER 61+95.98001	Both	Alignment	ERse:ERse	ERs EP_L Tied to SE Return
X	1	EP_R	ER 61+19.57600	ER 61+95.97972	Both	Alignment	ERsw:ERsw	ERs EP_R Tied to SW Return

Pause for a moment and consider what will happen to the main body of this section when the EPs are repositioned to the return PC and PT by the **POINT CONTROLS**.



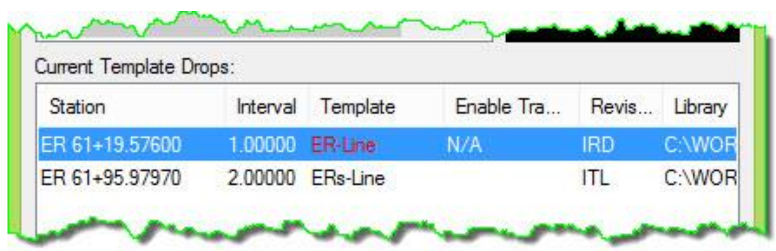
The answer is contained in the point constraints that are weaving the points together between the left and right EPs.

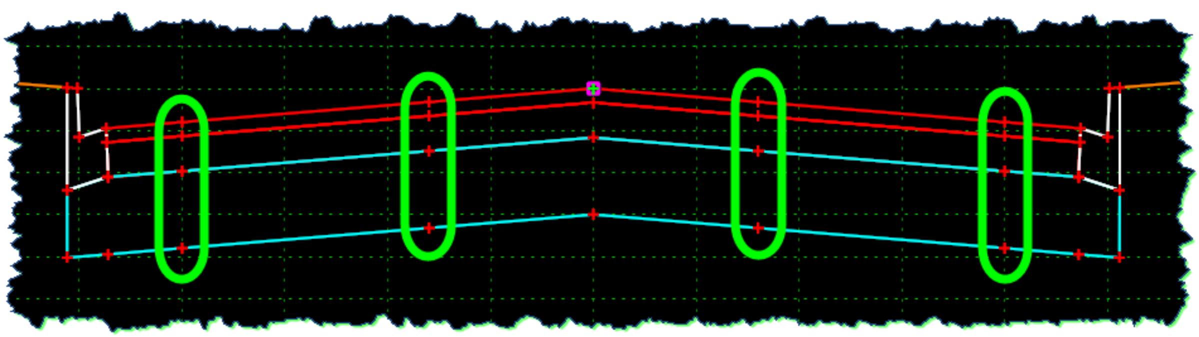


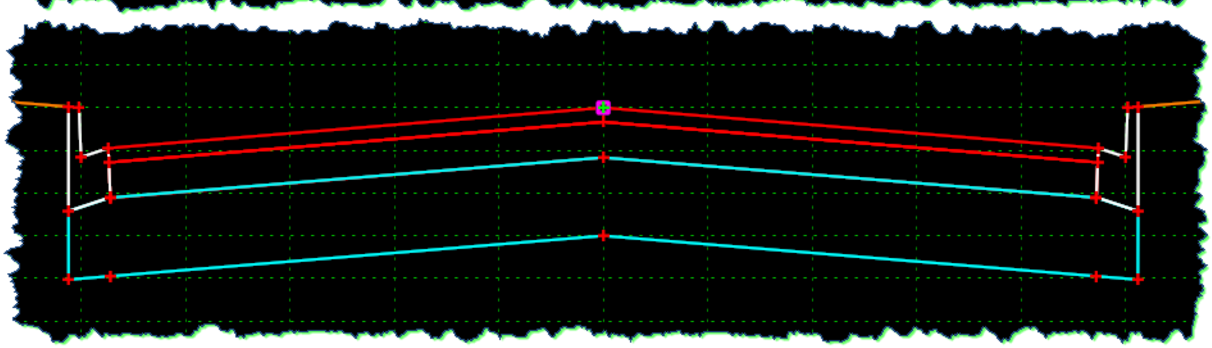
In the case of these templates, the travel lanes and EPs are constrained by a **Vector-Offset** from the median slope. That won't work here. This tie-in to the primary road will be discussed more at the end of this module, but suffice to say for now, these constraints won't work at this station with these **POINT CONTROLS**. Please discuss this with someone if you do not understand exactly why this is true.

For this model, these points will be removed from this area of the modeling. The other alternative is to develop specific **POINT CONTROLS**, **Constraint Value Equations**, or **PARAMETRIC CONSTRAINTS** to control their movements that are more conducive to the desired grading in this intersection.

5) Delete the template points identified below from the first template in this corridor through the IRD and fully constrain the EPs to the centerline.

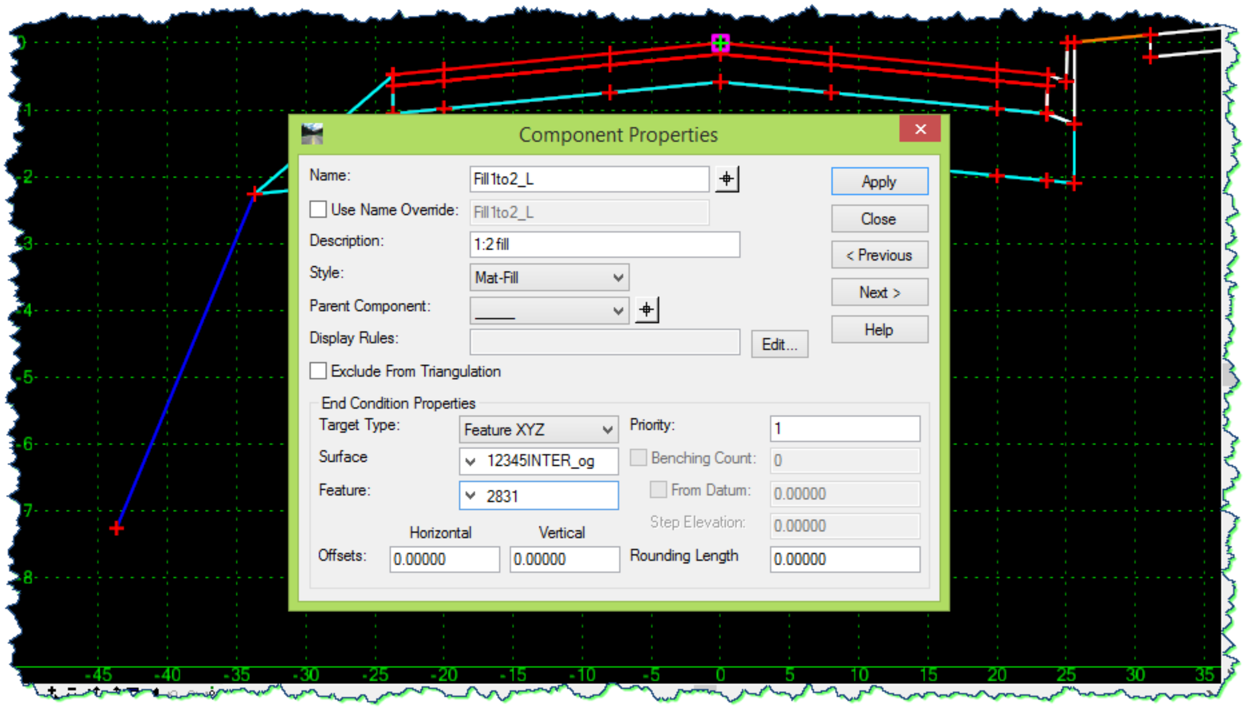




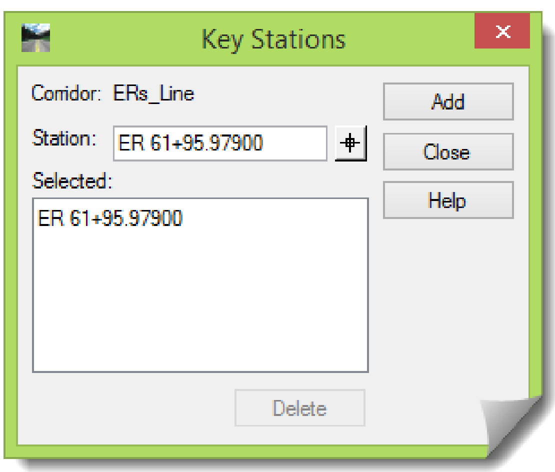


6) [**Edit**] the second template drop and change the **Target Type** on the **`Fill1to2_L`** component to **Feature XYZ**. Set the **Surface** to the OG, and the **Feature** to `2831`.

Feature **`2831`** in the OG surface is the feature that represents the flowline of a ditch. This will tie the new side slope, after the return, to the flowline of the existing ditch in the SE corner.

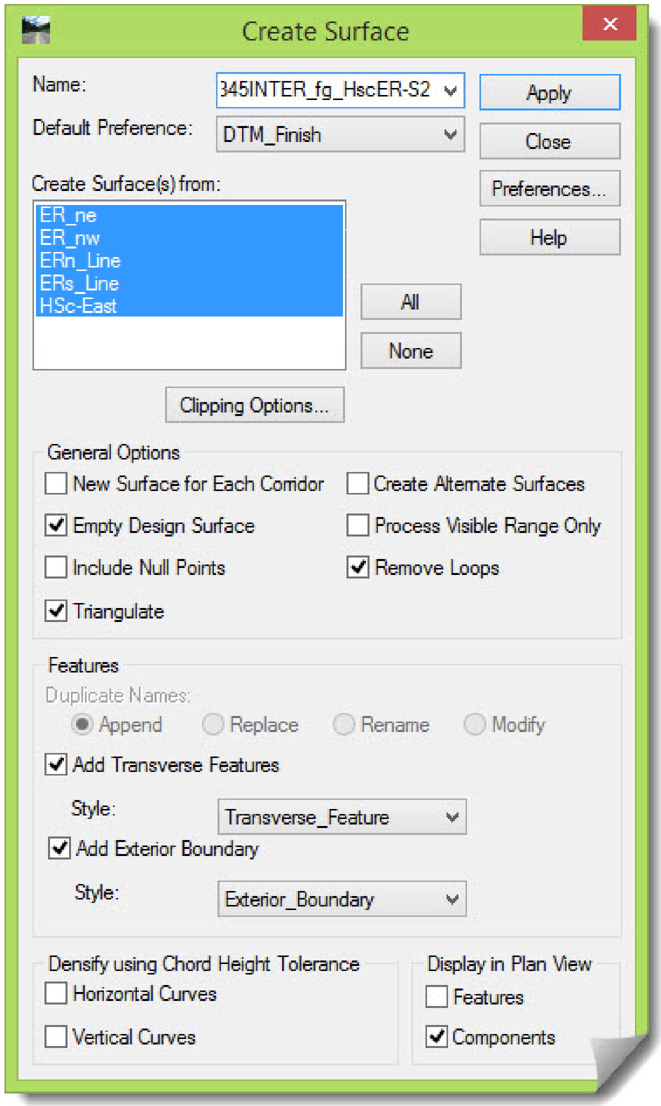


7) Add a **Key Station** at `61+95.9790` as the last modeling station for the template running forward from the primary road.



That's the entire corridor configuration that will be done for now. The next step will be to create a composite model of all the corridors that have been created so far, and develop a combined design surface containing both the southerly and northerly intersections.

8) Create a composite surface called **12345INTER_fg_HscER-S2**.



9) [**Close**] and [**Save**] the **Roadway Designer** and view the surface results.

You should find a few areas that need some improvements. There is one area at the southeast return where it meets the primary road that needs additional work. That point control is not catching the return at the first template drop along the secondary road, so it's shooting out the curb & gutter, sidewalk and ECs perpendicular to the initial template drop instead of perpendicular to the return. Adding an earlier template drop without starting the components beyond the EP would begin to clean up that area.

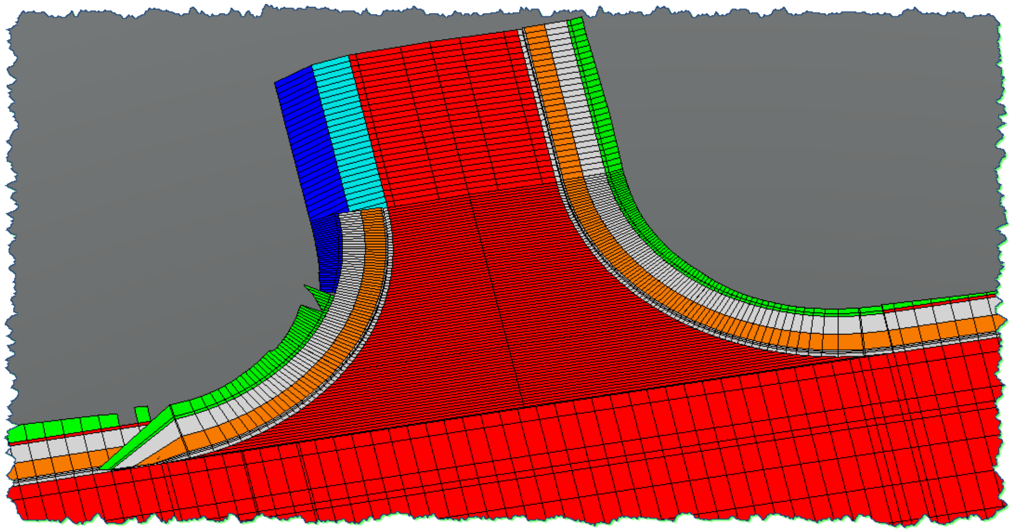
Another area is at the south end of the return that requires a transition from the sidewalk / curb & gutter section to the ditch section.

10) [**Save**] the design surface before moving on.

Rather than give you a perfect set of steps resulting in a clean model, the approach taken was to quickly define the model as you would expect to configure it. The next portion of this module will be the steps that would be done in locating, analyzing and cleaning up the model. Eventually, you will learn to anticipate problems and configure the model in more detail at the start.

Modifying the Model

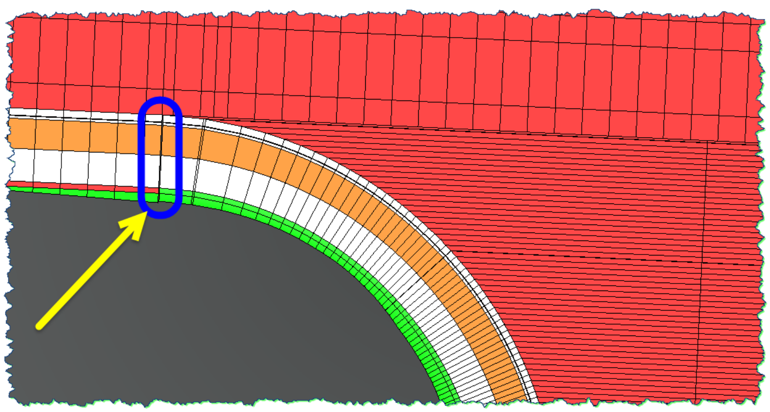
Here is what the model should look like so far:

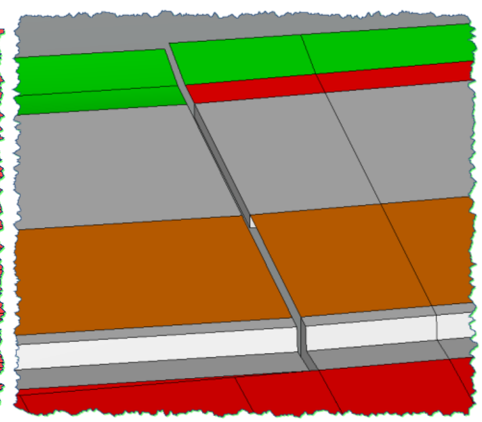


Now some cleanup to the model will be done. As more experience is accumulated, the cleanup will lessen. Regardless, it is very common to create models with as much intelligence and insight as you have, and then revisit the **ROADWAY DESIGNER** for minor adjustments.

Area #1

Let's address this item first (there is a gap between the modeling at the start of the SW return):

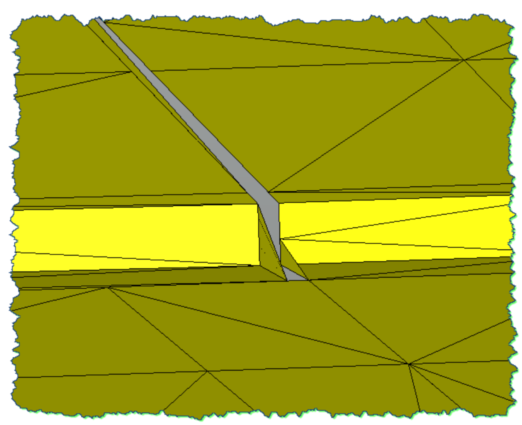




If the triangulation is viewed, it is also observably in need of attention.

Gaps like these are usually 'repaired' by either adding a **KEY STATION** or adjusting the **TEMPLATE DROPS** in some way.

Regardless of the 'repair', it is typically necessary to determine the stationing limits at the start and end of the problem in order to diagnose and eventually apply a solution to the area.



1) Do an analysis of the area and see if your results are similar to the upcoming steps.

   You should at least validate that the information below is what you are seeing. If yours is different, apply your values to the solution.

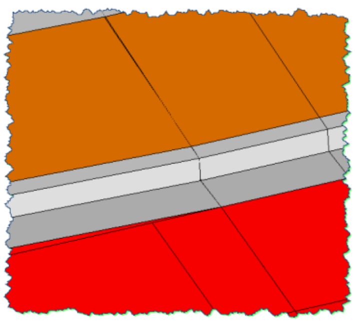
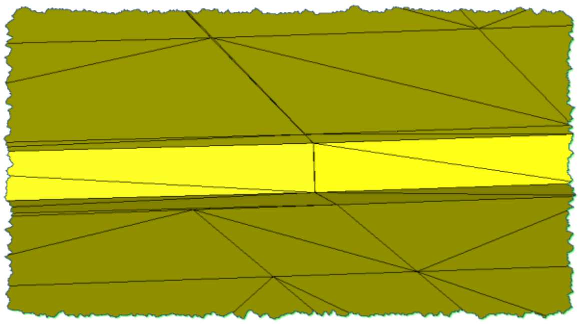
   Determining the stationing of the gap along the primary road results in this:

   - Start of gap = Station `518+23.04300`
   - End of gap = Station `518+23.25081`

2) Apply these changes to the `HSc-East` corridor in the **Roadway Designer**:

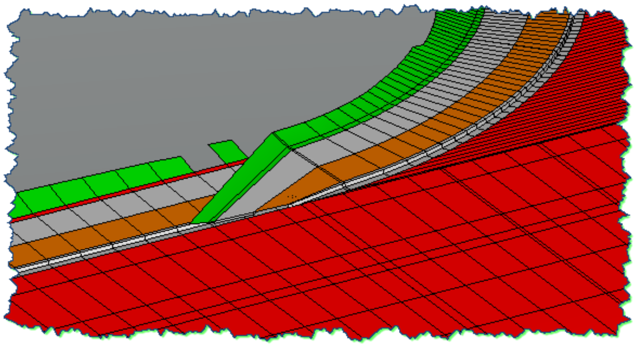
   - Modify **Template Drops** to allow the second template drop (prior to the gap) to run a bit further by changing the third drop from `518+23.0434` to `518+23.2508`
   - Add a new **Key Station** at the end of the gap at Station `518+23.2507`
   - Remove the current **Key Station** at `518+23.0430` (this is optional)

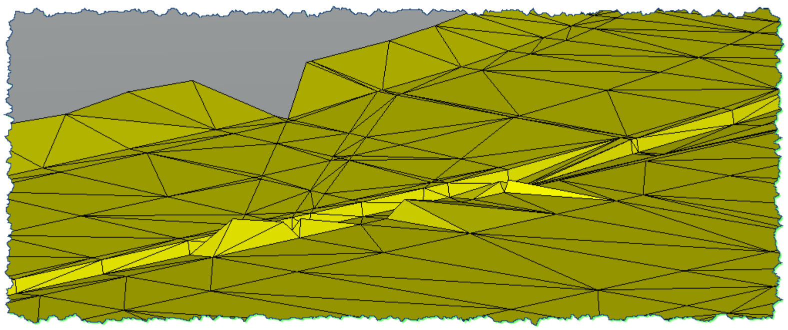
3) After recreating the surface, the components and triangulation should look fine.

Area #2

The next area to fix is the other return as it converges with the primary road. There is almost no need to review the triangulation here, because it's obvious by looking at the components that something is wrong. The triangulation confirms a modeling problem.



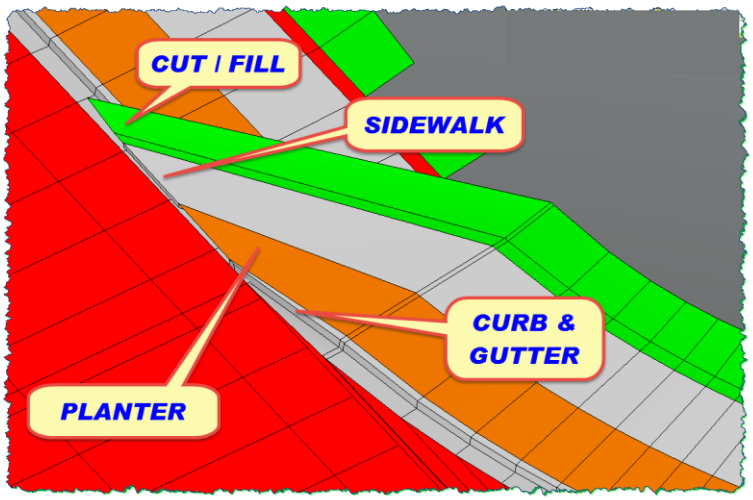


With an issue like this, the best place to begin is to start modifying either the template drop locations or key stations (changing, removing or adding), and then check the influence of the edit.

As it was mentioned already, there is no substitute for experience, and the more that you run into issues like this the more likely you will be able to analyze the results, narrow down the problem and zero in on a potential solution.

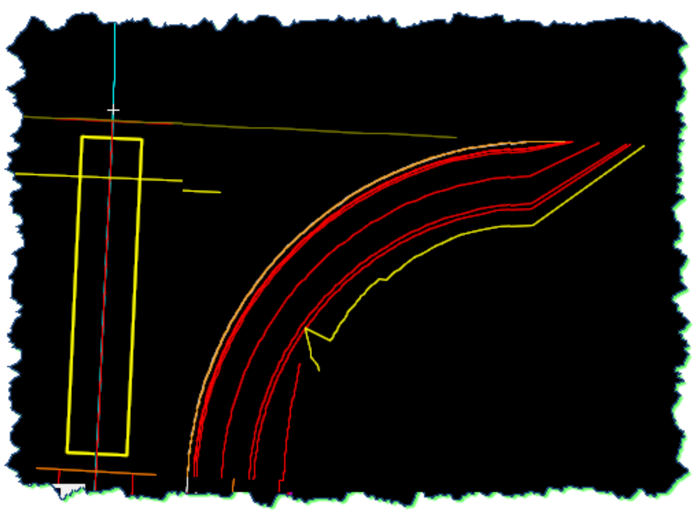
Noticing the way the components were oddly constructed reveals that the modeling was applying the curb & gutter, planter, sidewalk and Cut / Fill components perpendicular to the secondary road instead of perpendicular to the return alignment. This only seems to occur right at the beginning of the modeling. Further along the return, it is modeling correctly.

Can you think of what potential modeling settings in the corridor might apply to this?



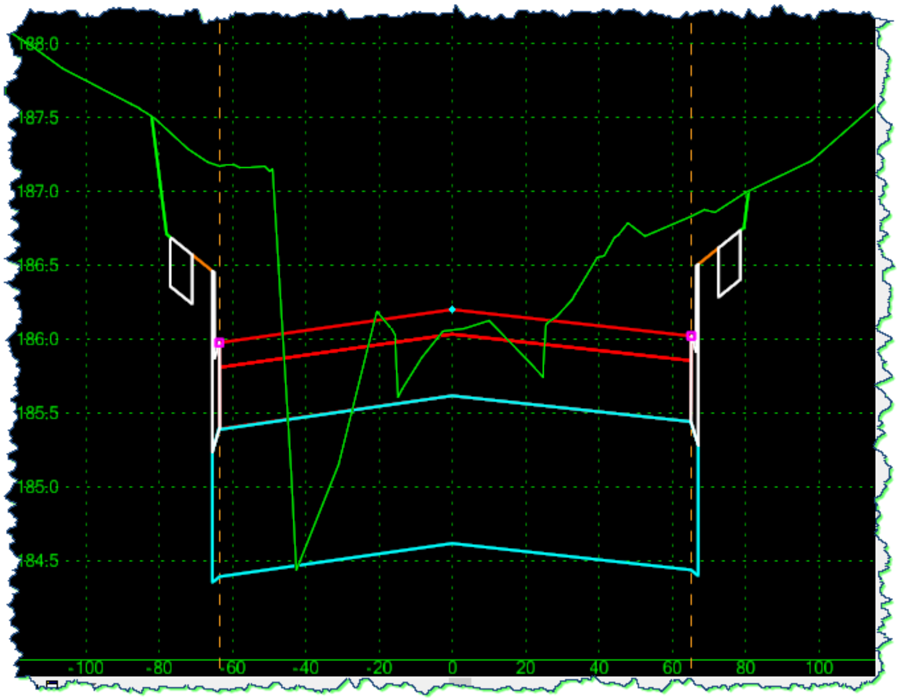
1) Open the **Roadway Designer**.
2) Set the **Corridor** to **`ERs_Line`** and [**Process All**].

Note that this problem is also clearly visible in the plan view window of the **Roadway Designer**.

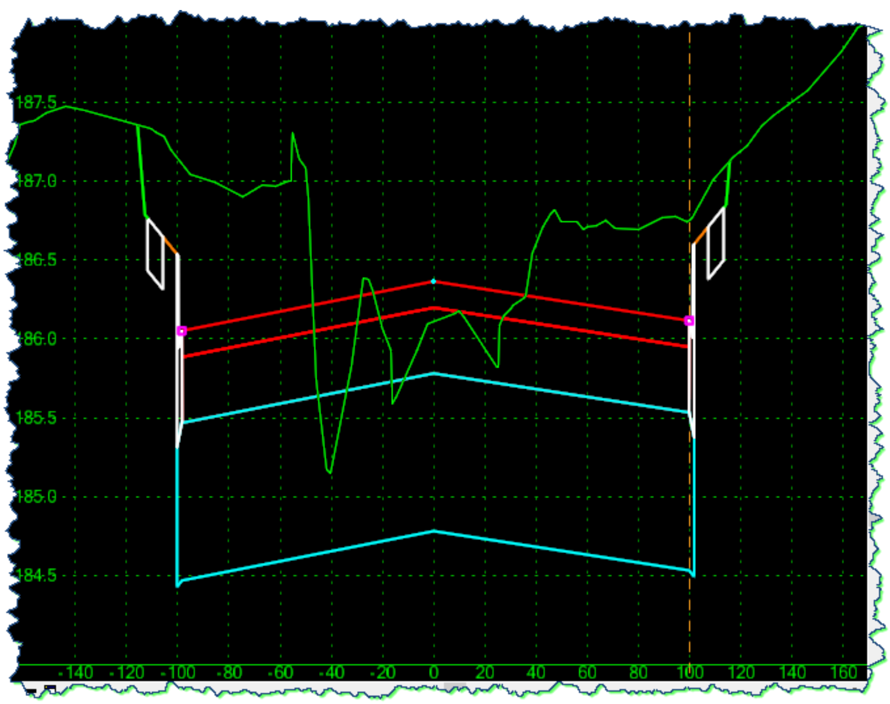


The suspicion here is that the template point **`EP_L`** that has the point control attaching it to the return is the root of the problem, since it's supposed to be connected to the return geometry and running perpendicular to that alignment. The majority of the modeling around that return is successfully modeling as expected.

Another clue to the problem and the solution is the Roadway Designer cross section view. This is a section along the return:



This is the first section of that corridor:



Do you see what's missing?

Do you know what the purple dots represent?

Do you know what the brown vertical lines represent?

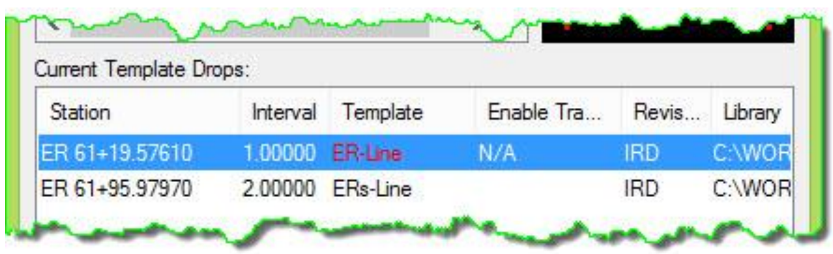
The purple dots indicate that a **POINT CONTROL** has been established for that template point.

The brown vertical lines indicate that a secondary alignment has gone into effect at that section. In this instance, it's the control lines for the point controls that have been defined.

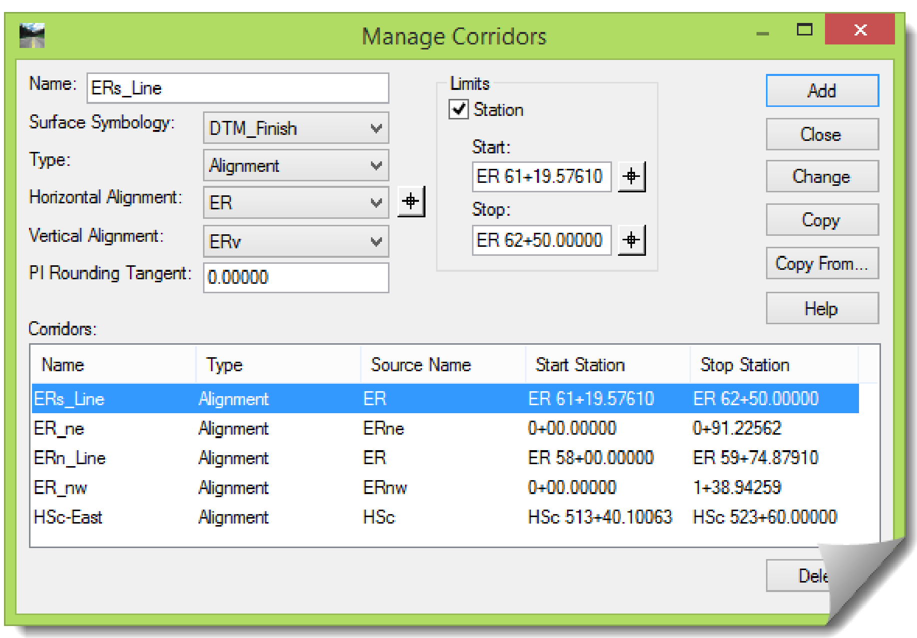
In this instance, the very first template drop can't find the **`ERse`** geometry used as the control. This could go back to an earlier topic, also covered at the end of this module, on precision. It should have been noticed that throughout this module an apparent ridiculous precision is sometimes shown, and sometimes applied. This is one aspect of InRoads that has to be dealt with when creating composite models such as this. Sometimes it matters, and sometimes it doesn't.

3) Open the **TEMPLATE DROPS** for the **`ERs-Line`** corridor.

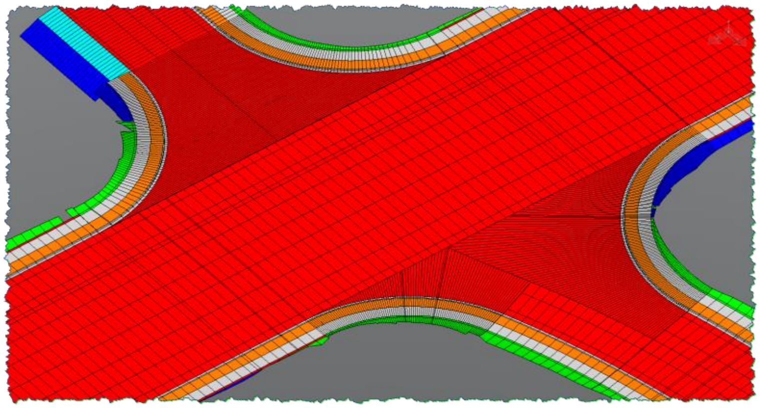
4) Change the first template drop to **`+19.5761`**, just slightly ahead of where it was.



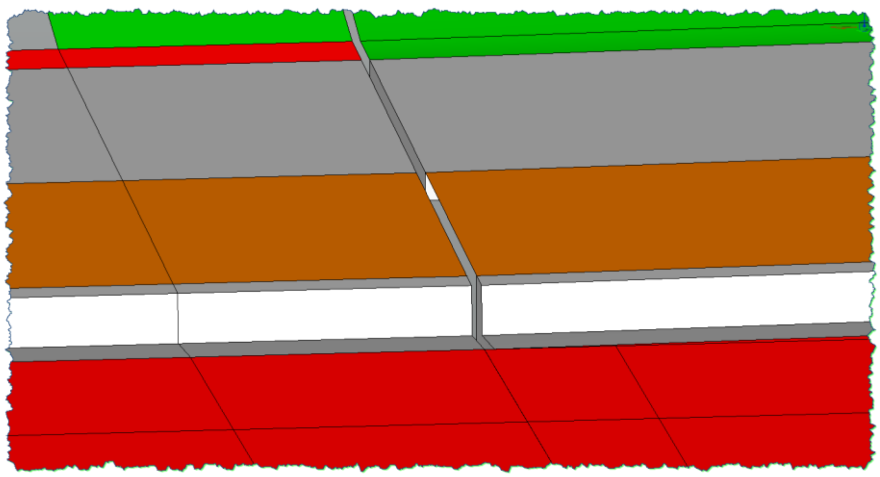
5) Also make the same precision change in the **MANAGE CORRIDORS**; otherwise, it will be missing a template drop at the start of the corridor. Even though it is such a small distance, it should be done, and will fix this problem.

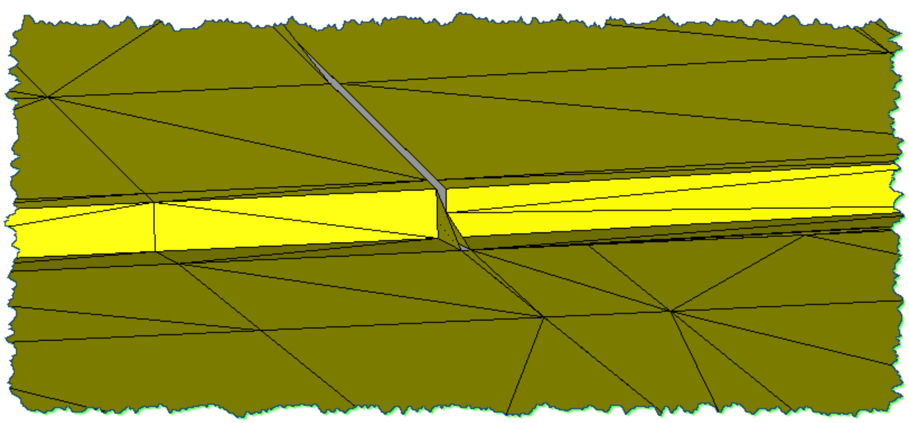


6) Review the results in the **ROADWAY DESIGNER**.
   - After a [**Process All**], the plan view in the **ROADWAY DESIGNER** should look reasonable
   - The cross section view in the **ROADWAY DESIGNER** should also look correct
7) [**Save**] the IRD and create a new composite surface and review the results.



8) Look closely at that particular area that was being addressed.





That area is now producing much better results, but there is now a small gap in the modeling due to slightly pulling back the return modeling. This can be addressed by determining the amount to adjust the primary road modeling in that area to close that gap.

Can you accomplish this without guidance?

Here are the basic guidelines:

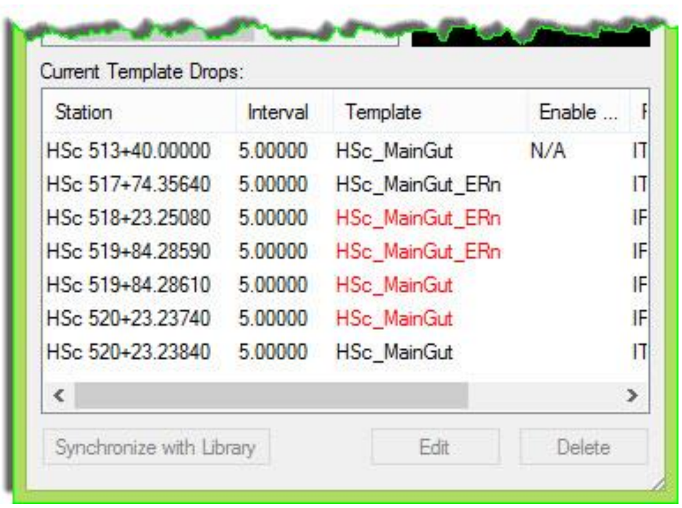
a. Determine any critical stations along any relevant alignments
b. Make any necessary changes / additions / removals to the **Template Drops** as needed
c. Make any necessary changes / additions / removals to the **Key Stations** as needed
d. Make any necessary changes in the **Manage Corridors** as needed
e. Make any necessary changes / additions / removals to the **Point Controls** as needed
f. Recreate and review the revised model

9) Define the critical stations for the gap.

Determining the stationing of the gap along the primary road results in this:

- Start of gap = Station **520+23.12145**
- End of gap = Station **520+23.23761**

10) Review the **Template Drops** for the **HSc-East** corridor to determine which entry (or entries) should be changed.

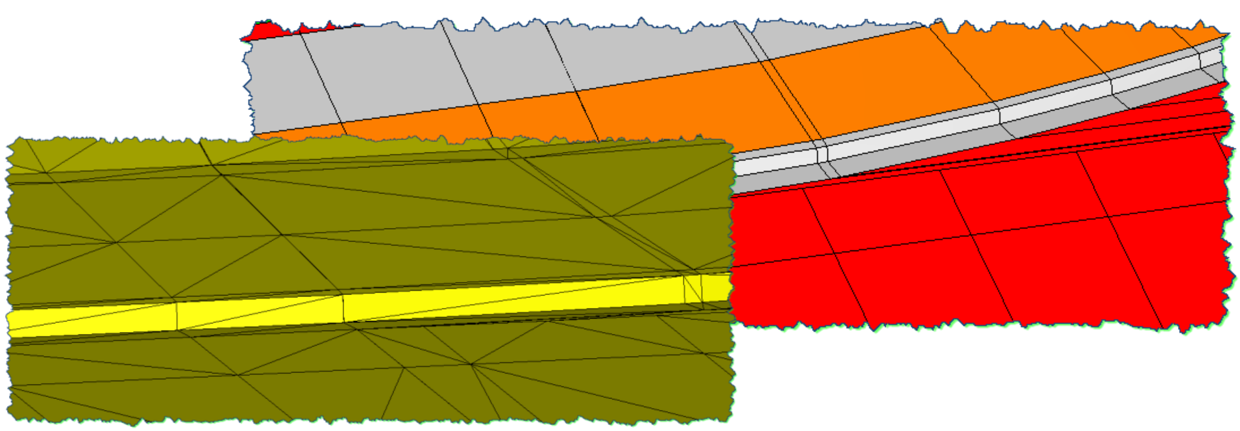


The intent would be to ensure a modeling drop from the primary road as close to the start of the gap as possible, without conflicting with the modeling of the secondary road. This gap modeling must contain a section with the curb & gutter and other components right of the **EP**.

11) [**Change**] the entry at **520+23.2374** to **520+23.12145**

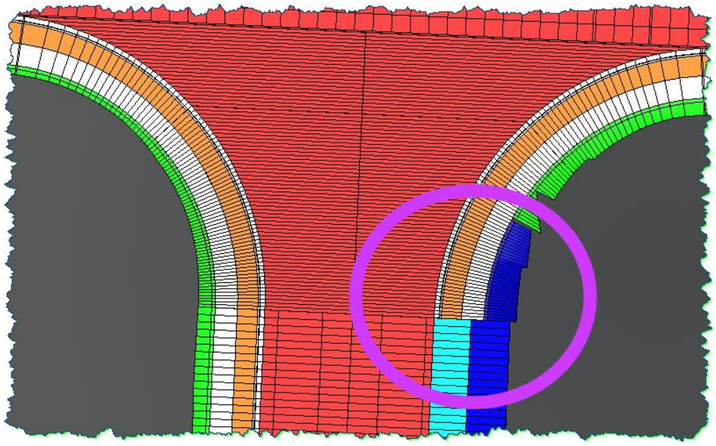
12) [**Change**] the entry at **520+23.2384** to **520+23.12155**

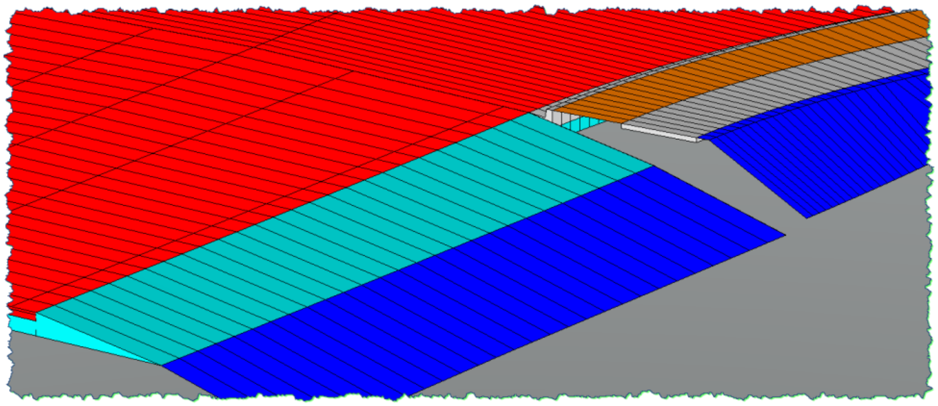
13) [**Save**] the IRD and create a new composite surface and review the results.



Area #3

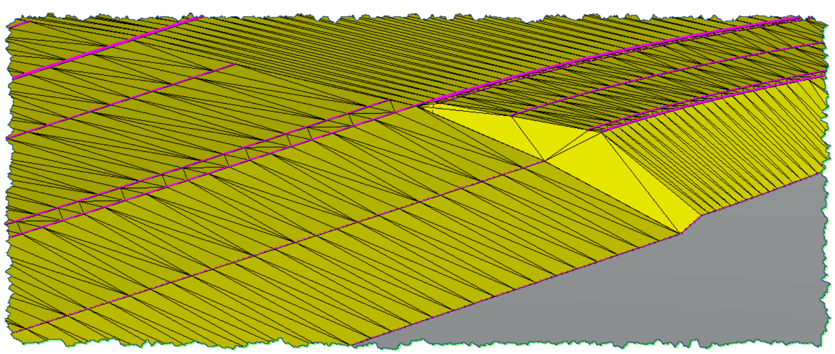
The last piece of the intersection cleanup will be the transition from the return to the slope tie-in with the ditch. Right now, it is abrupt.



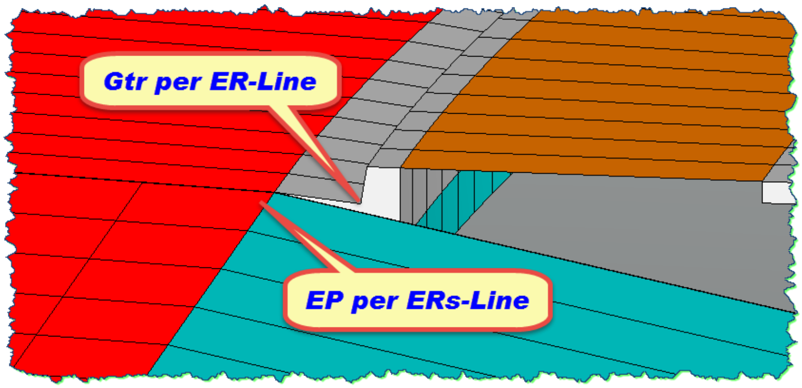


There is nothing special about creating this transition, and it is addressed like every other transition in InRoads, requiring some additional definition on how the template points from one section transition to the next different section and inserting any transitional templates as needed. In this example, there might be more details involved in this transition for safety purposes, or future development or any number of variations that could cause this transition to be created differently.

Looking at the triangulation in this area doesn't reveal any dramatic problems, and if an abrupt transition is acceptable (which might be a short wall), this model is more or less complete. Otherwise, the transition here will need to be addressed.



Before the last area is addressed, a related adjustment is the lining up of the EP on the template and the gutter line of the template moving around the return.

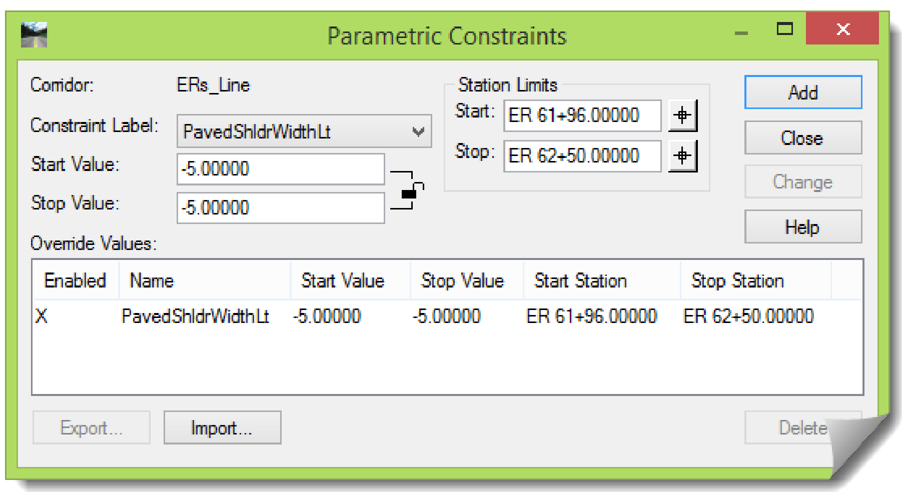


There is a **Label** on the **Horizontal Constraint** called **`PavedShldrWidthLt`**. This will be used to widen the **`EP`** so that it matches the **`Gtr`**.

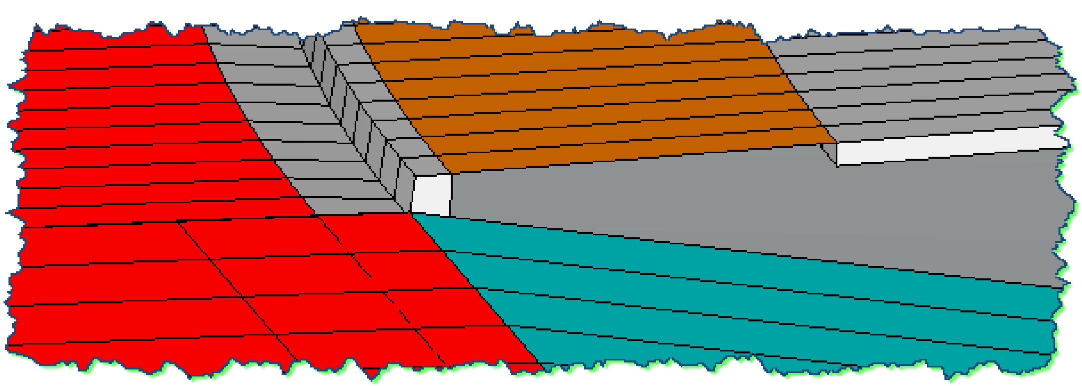
All that needs to be done is to add the **`EP`** to **`Gtr`** distance from the **`ER-Line`** template to the current **`EP`** distance on the **`ERs-Line`** template. In this instance that distance is **`1.307'`**.

This **Parametric Constraint** will be applied from the start of that template drop until the end of the model, station **`61+96.00`** to station **`62+50.00`**.

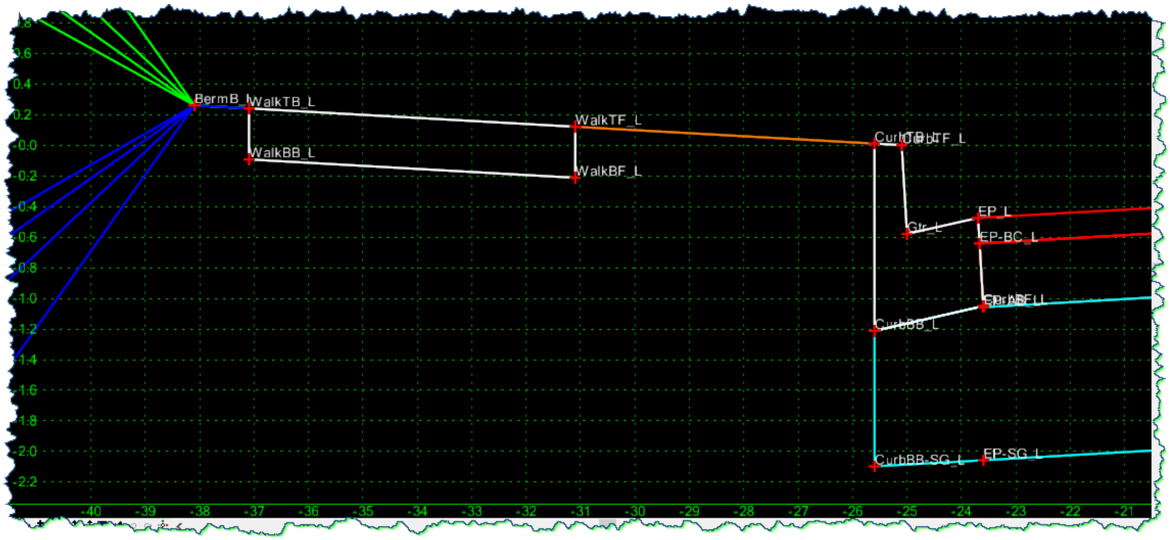
14) [**Add**] the **Parametric Constraints** as described above.

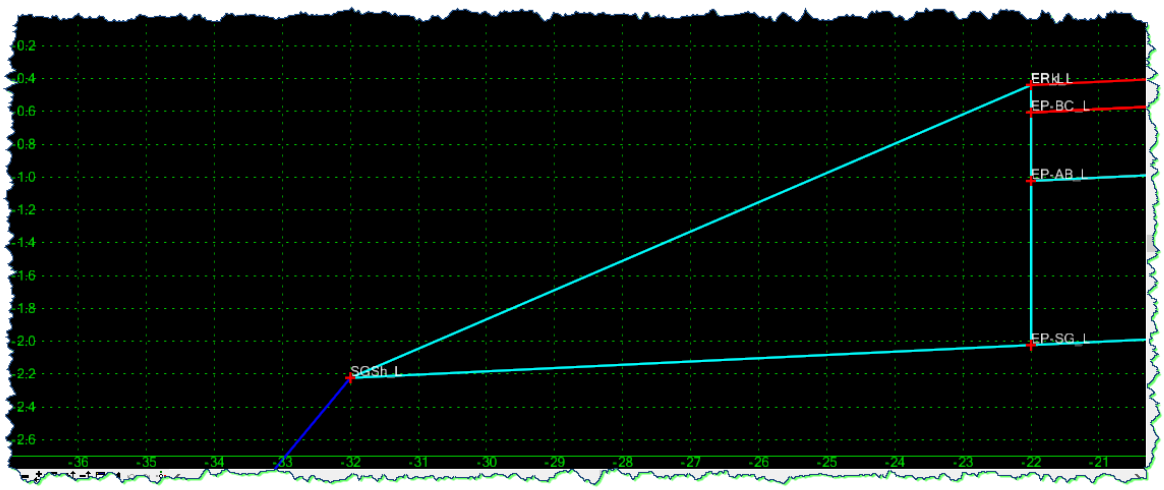


These **Parametric Constraints** settings will line up the **`Gtr`** and **`EP`** at the end of the return.



Now we'll address the modeling transition from the curb & gutter / sidewalk template to the ditch template on the left side (SE corner of the intersection).





The plan will be to leave the last full section of curb & gutter, planter, and sidewalk ending at the end of the return. From here, a few new templates will be created to transition to the 'ditch matching' slope. The full transition will take place over a distance of about **18'**.

These modeling edits will be done to the secondary road corridor, and will include addressing the curb face and parametrically reducing the curb exposure to **0.00** over **6**'. At that location, the curb will end.

15) Open the **Roadway Designer** and set the **Corridor** to **ERs_Line**.

The next few steps will relocate one of the templates, moving it forward, and leave room to insert another in its place. Keep in mind that there are different techniques to accomplish the same results here. At this stage, you should understand the end-goal and use whatever technique you feel is most efficient for you.

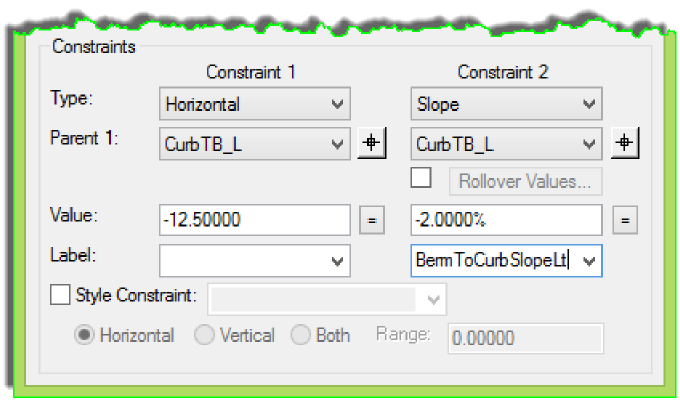
16) Go to the **Template Drops** and [**Change**] the **Station** of the second template drop, **ERs-Line**, an additional **18'** from **61+95.9797** to **62+14.00**.

17) [**Add**] a new template drop at **Station** **61+95.9797** using the **ER-Line** template, and disable the transition.

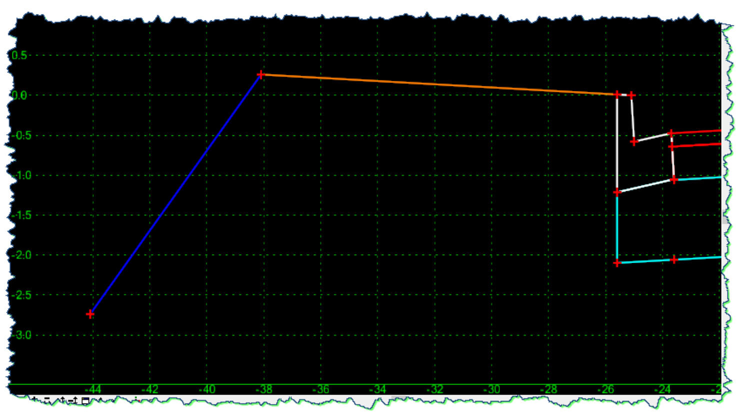
This template will be modified and applied over the next 6'.

18) Select the template just added and then [**Edit**].

- Delete the sidewalk component
- Delete all of the **`Cut`** components (in this case it is known that they will not be needed)
- The last fill slope to solve was **`Fill1to2`**, and the ditch is slightly deeper than that, so in this instance delete all of the **Fill** slopes except for the **`Fill1to2`** slope.
- Delete the **`WalkTB_L`** template point
- Move the remaining **`WalkTF_L`** point on top of the **`BermB_L`** point
- **Merge** the two points, deleting the **`WalkTF_L`** point when prompted
- Constrain the **`BermB_L`** point to the **`CurbTB_L`** by **Horizontal** and **Slope**
- Change the **Horizontal Constraint** value of **`BermB_L`** to **`-12.50`**
- Add a **Label** onto the **Slope Constraint** of **`BermB_L`** called **`BermToCurbSlopeLt`**. This will be used to control the slope of this component so that it matches with the next template.



The result should look like this:

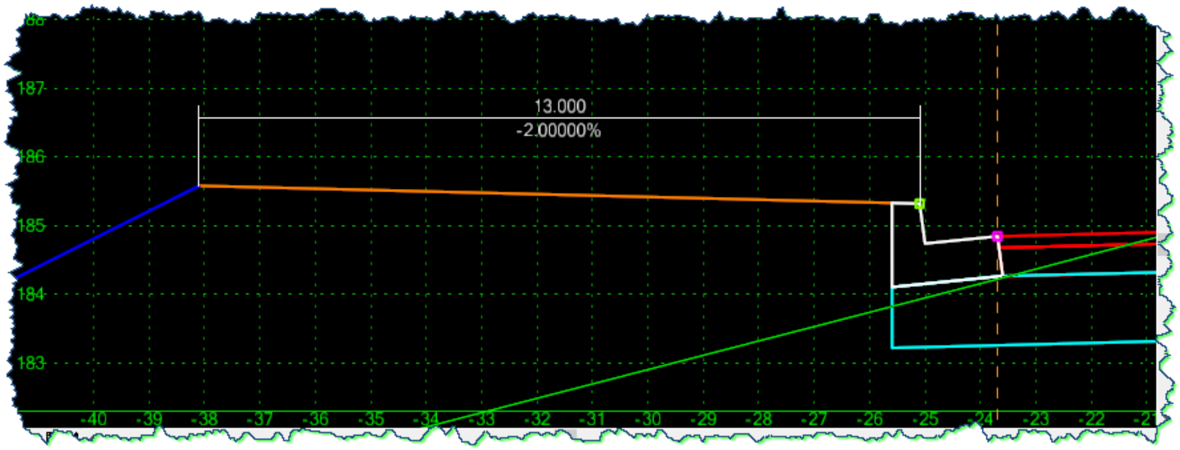


19) Select [**OK**] after those template edits are done.

At first, it was expected that the transition from the return template to the ditch template could be done primarily with **Parametric Constraints**. However, it seemed to require constraints that went beyond the complexity of simply adding one more template drop. It would be a good exercise to see what it would take to accomplish the following transition with only **Parametric Constraints**, eliminating the next template drop. In this approach, however, one more template will be used for this transition.

20) [**Add**] a new template drop at **Station** 62+02.000 using **ERs-Line** with a 2' **Interval**, and make sure the transition is enabled on the last entry.

This is going to be a transitional template between the end of the return template and the ditch template. The one edit that will be made to this template is the width of the rock shoulder, **ERk_L** point. For simplicity of modeling, this point will be moved outward to match the distance of the **BermB_L** point from the previous template drop. That point is **13.0'** from the **CurbTF_L**.

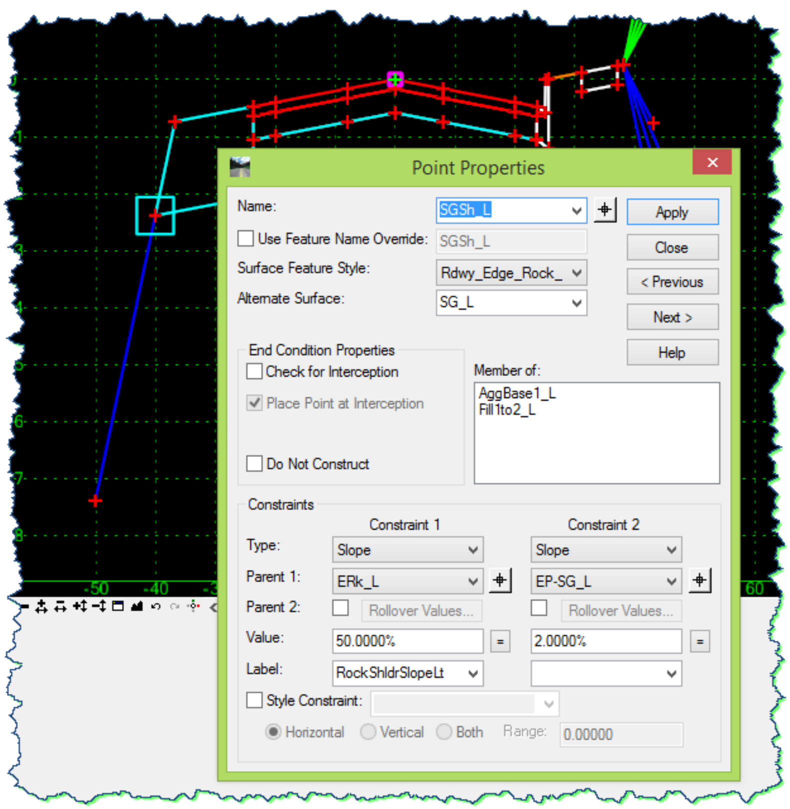


21) [**Edit**] that new template drop at 62+02.000 and change the **Horizontal** distance on that Constraint to -13.000 and [**Apply**].

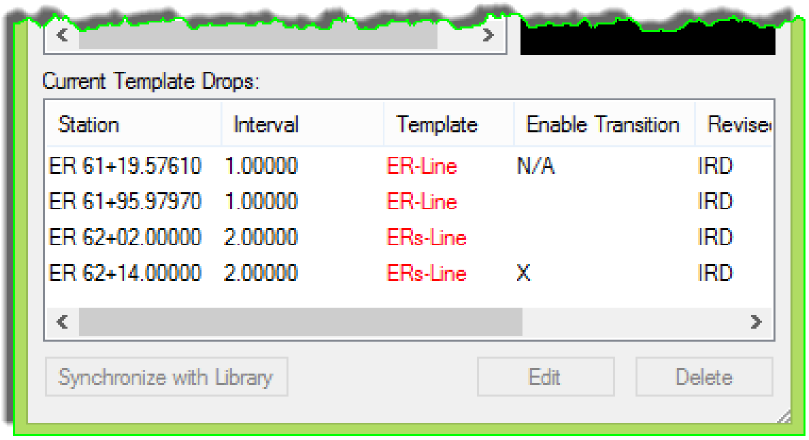
This template location is matching to the template coming off the SE return. The fill slope at the end of that return is 50%, and we want to match the rock slope to the fill slope.

22) Go to the **POINT PROPERTIES** of subgrade shoulder point, **SGSh_L**.

23) Change the **Slope Constraint** with **ERk_L** as the **Parent** to 50% to match the fill slope at that location.



The two changes just made will be part of a template transition between stations **62+02.000** and the template drop at station **62+14.00**, which will be reviewed and edited later.



24) [**Close**] the **Template Drops** dialog box.

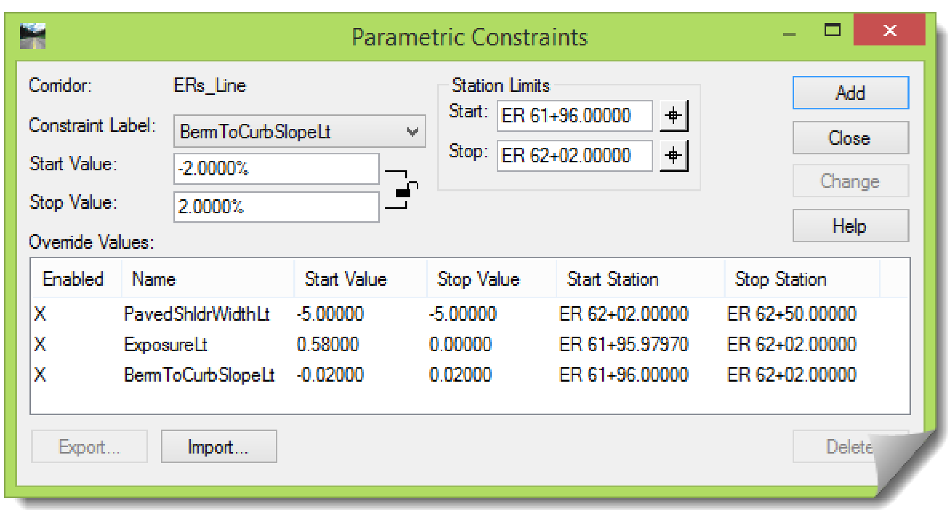
Next, adjustments will be made to a few settings defined earlier in this module, as well as adding a few new settings. This is common when solving unanticipated modeling details.

25) [**Change**] the **Parametric Constraint Label PavedShldrWidthLt** to a **Start** station of **62+02.00**.

While in the **Parametric Constraints** tool, adjust the curb height of the template at the end of the return so that it transitions to **0.00** over the 6' of transition.

26) [**Add**] an entry for the **ExposureLt** from the normal height to **0.00** from station **61+95.9797** to **62+02.00**.

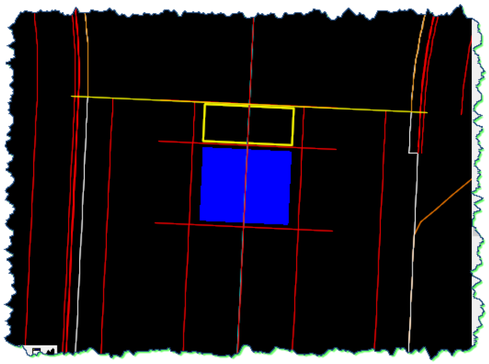
27) [**Add**] another entry to transition the template slope at the end of the return to match the slope of the next template drop. The **Constraint Label** is **BermToCurbSlopeLt** and it should **Start** at **-2.00%** and **Stop** at **2.00%** from **Station 61+96.000** to **62+02.000**.



28) [**Add**] a **Key Station** at **62+01.999** to carry the transitional template right up to the template located at station **62+02.00**.

That should do it for the corridor configuration details, and the last item is to verify that the transition will work properly between **62+02** and **62+14**.

What does a blue transition band mean?



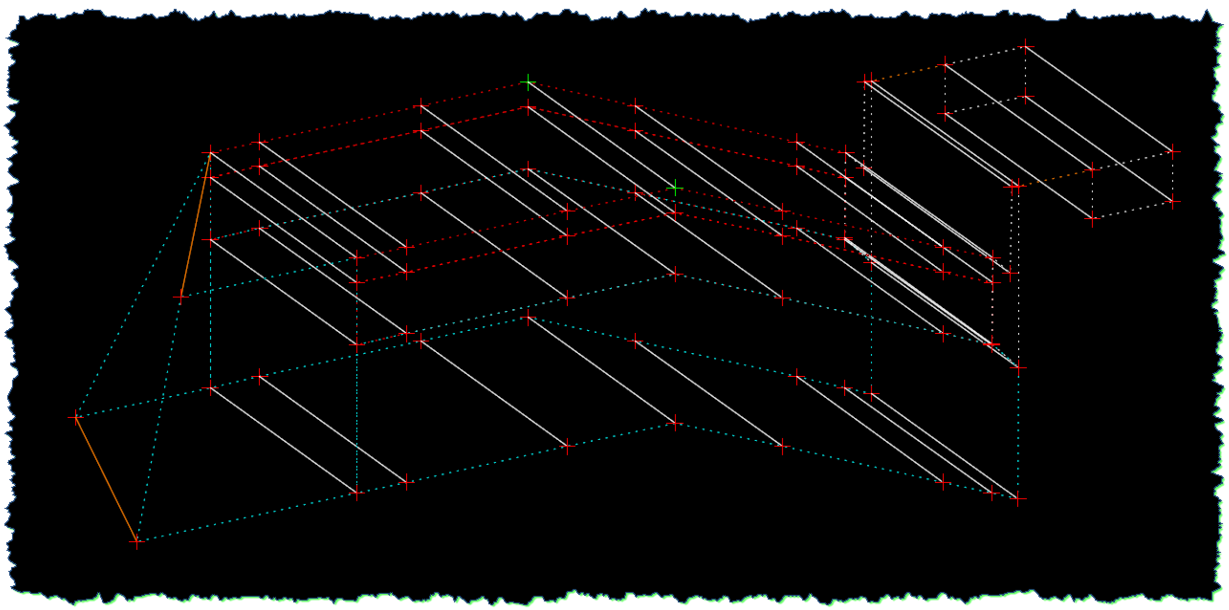
It means that InRoads was able to connect all of the template points from one drop to all of the template points on the next drop.

So why check it?

Because the transition itself may not actually work due to being over-constrained.

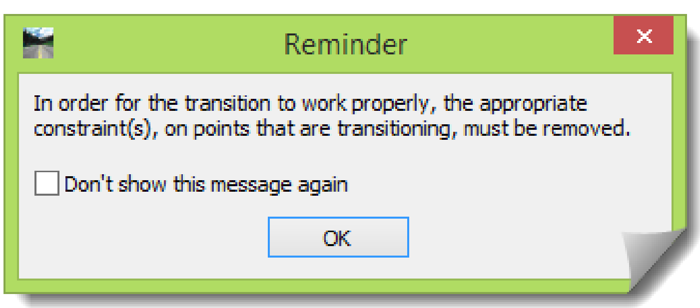
29) Double-click on the blue transition band in the plan view window.

It's observable that all of the template points are connected between both templates.



30) Select [OK] to move to the next window.

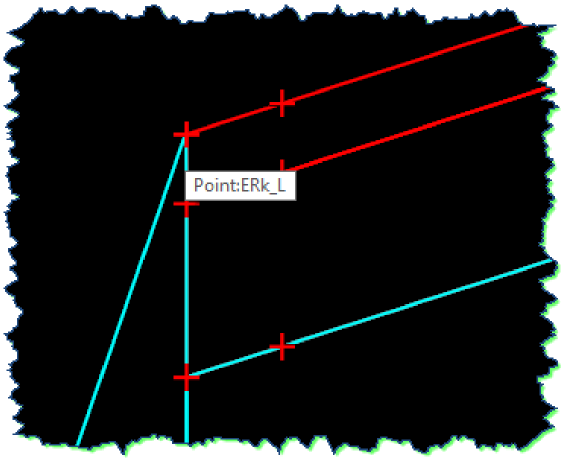
If it's not disabled, the **Reminder** message should appear.

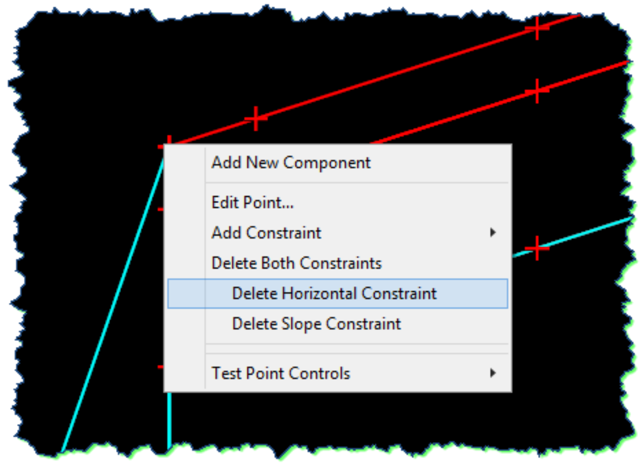


31) If you test the transition with the lower slider bar, you will discover that the transition is not working as desired. That indicates that some constraints will have to be removed to provide enough flexibility for the transition to work.

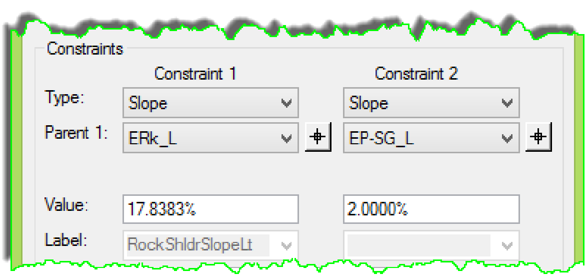
Considering the transition itself and the templates used, the **ERk_L** point needs to be able to move horizontally in order to move toward the **EP**. In addition to that, the **SGSh_L** point needs to adjust its slope toward the **ERk_L** point so that it can flatten out as the **ERk_L** point moves toward the **EP**.

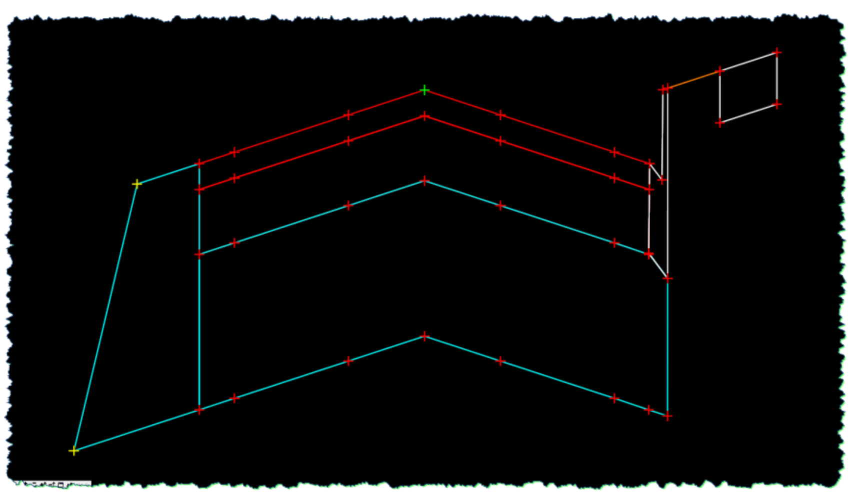
32) Locate the **ERk_L** point and right-click on it, and **Delete Horizontal Constraint**.





33) Next, edit the **SGSh_L** point and set the **Type** to **None** on the **Slope** to the **Parent** named **ERk_L**.





34) Select [**OK**] when complete.

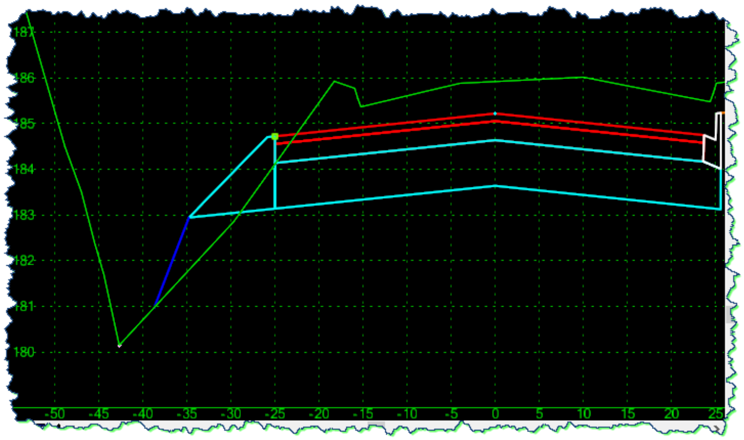
Final Cleanup

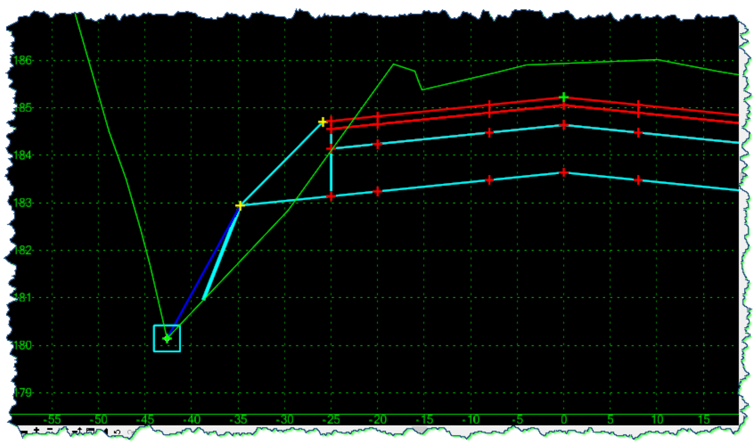
1) Review the results so far and see if there are other areas requiring cleanup.

You may find a few areas on the cut / fill slopes that require some **End Condition Exceptions**.

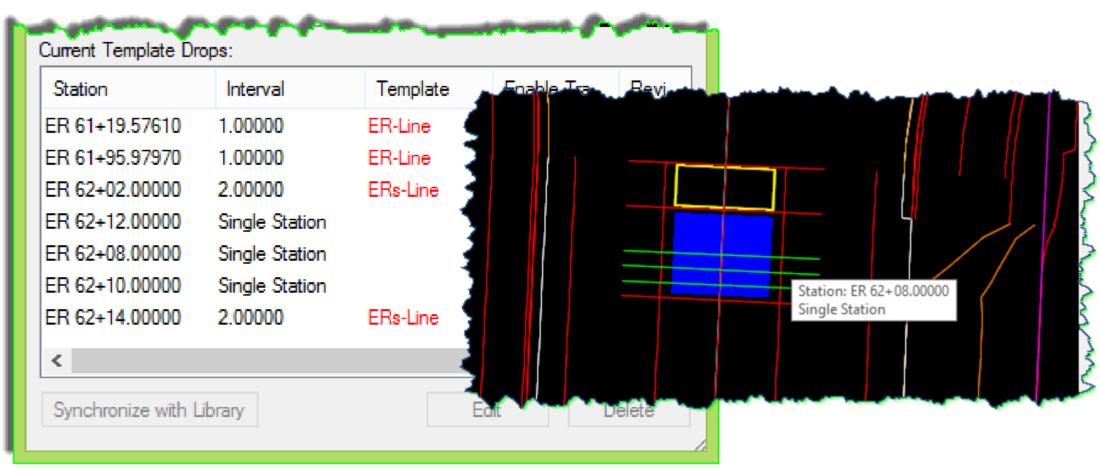
2) There are a few stations that could use a single station edit, like **62+12.00**, where it would be better if the toe of fill were catching the ditch flowline.

These can be edited as single cross section edits.



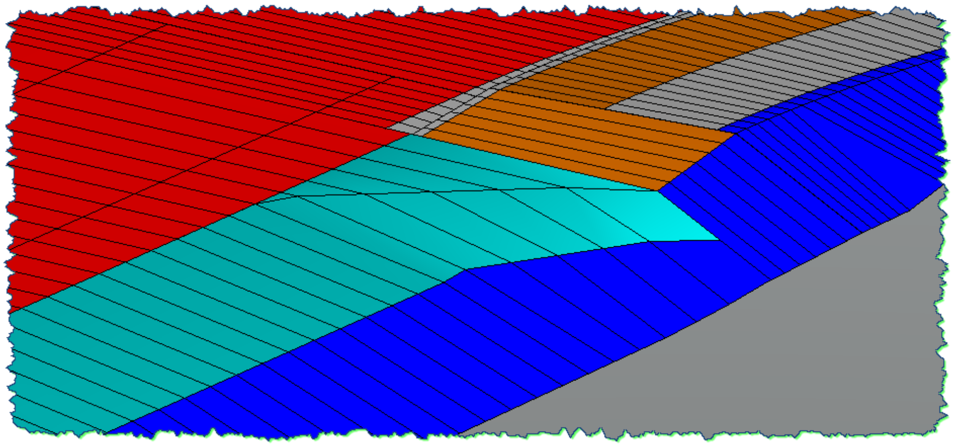


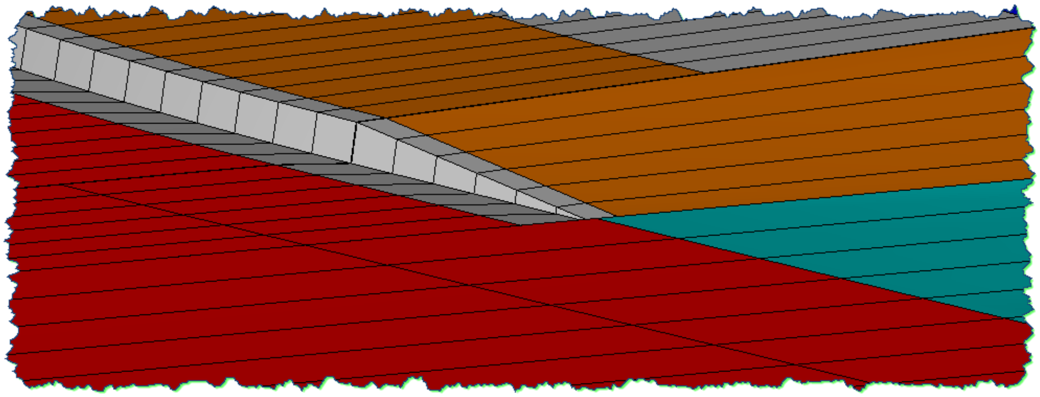
Any edit of this type will show up in the plan view window as green lines, as well as showing up in the **Template Drops** dialog box. Just keep in mind all of the rules regarding these types of edits.

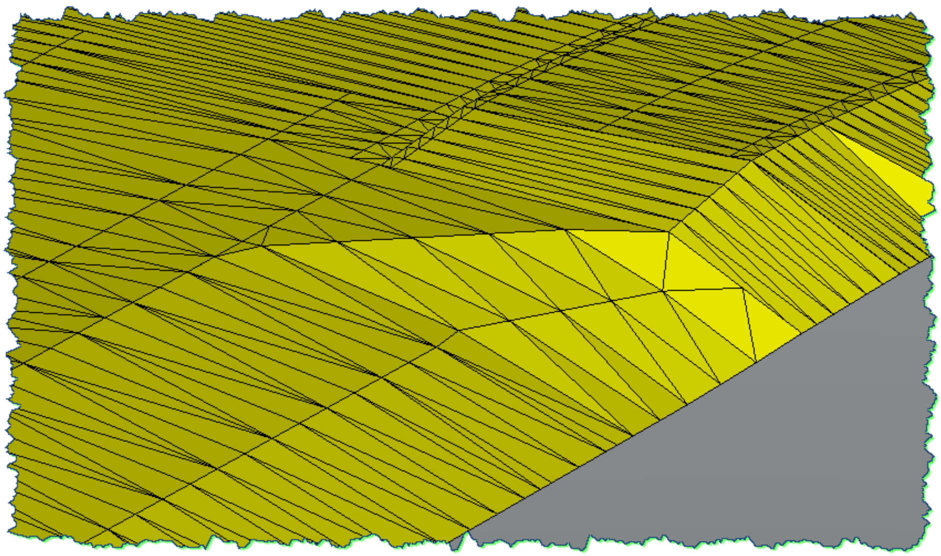


3) Recreate and display the updated surface.

The results for this area are shown here:





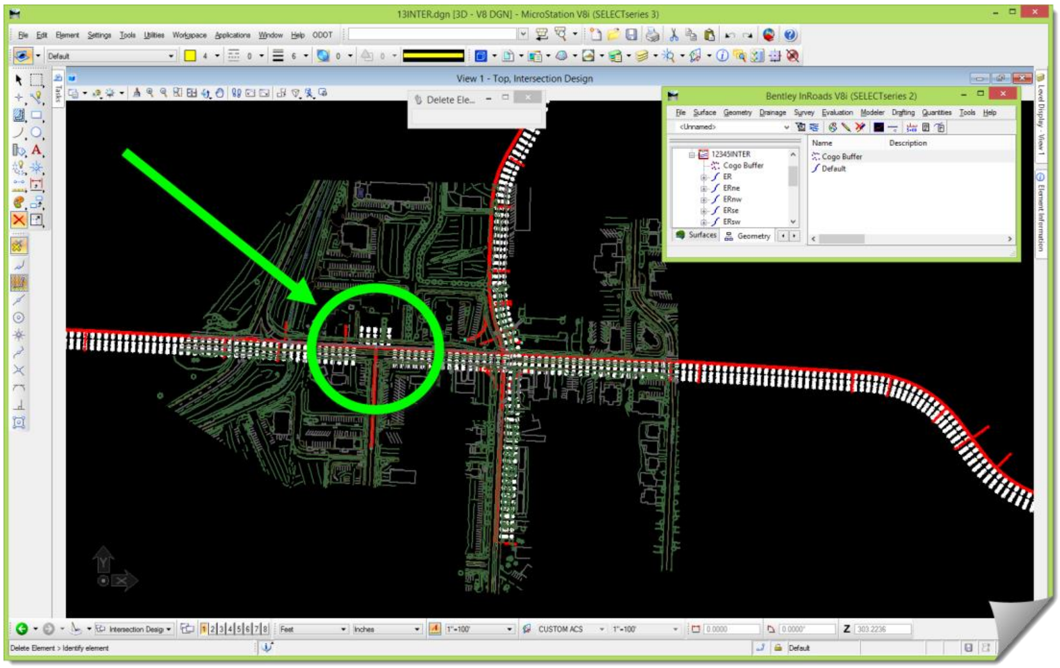


SCENARIO 3 - APPROACH INTEGRATION

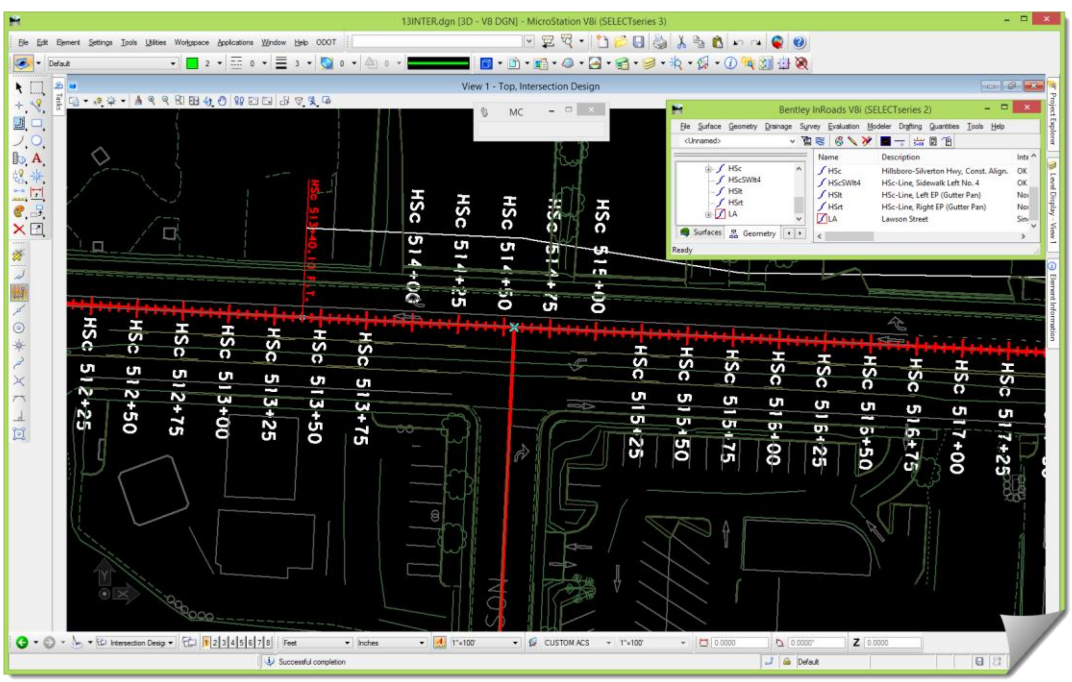
This last scenario will involve modeling a primary roadway and integrating an existing side road approach into the primary road model. In this situation, the grades should be matched in at some distance back onto the approach.

We're starting with the primary corridor from the last scenario, as well as all of the earlier geometry. In addition, we have geometry already established for this major approach.

1) Locate the area of work for this scenario.



2) View the horizontal geometry for orientation (**LA**, and **HSC** if it's not already displayed).



Creating Curve Returns

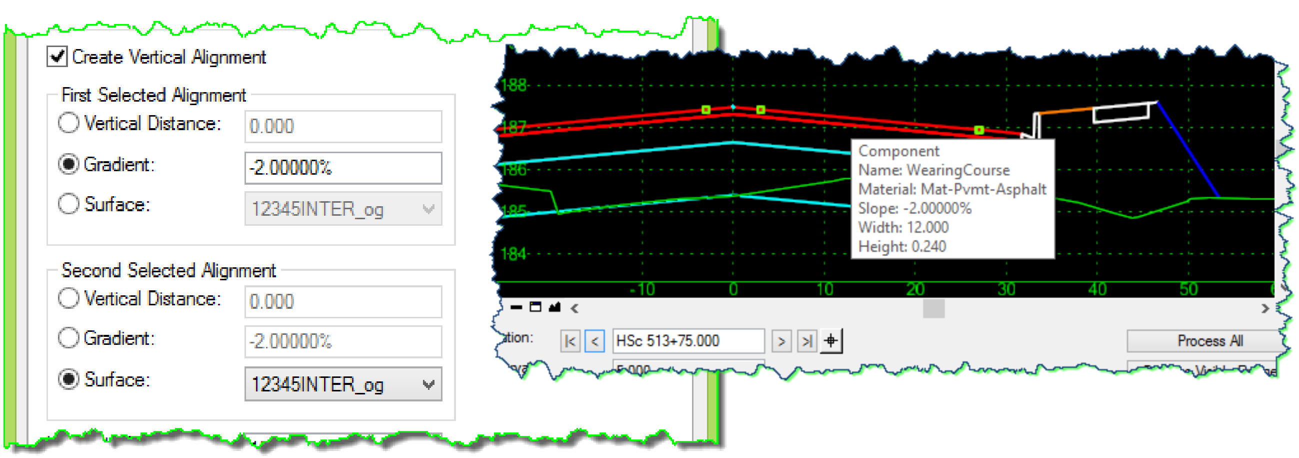
1) As done earlier, use the **Multicenter Curve** tool to construct the horizontal and vertical alignments for the returns on either side of the approach.

The only difference will be when creating the **Vertical** alignment. In this case, the **Second Selected Alignment** will use the **Surface** option as the OG to develop the vertical alignment, not the vertical alignment of the approach itself (since in most cases the vertical alignment of the approach won't exist).

> **TIP**: If a secondary road were superelevated, the **Multicenter Curve** tool would still be used to create the returns after the Superelevation was established. Once the secondary road 'core' was defined, a temporary surface would be created. The **Multicenter Curve** tool would then build the returns from the temporary secondary surface instead of its vertical alignment.

2) Calculate your own information and compare it to what is shown here:

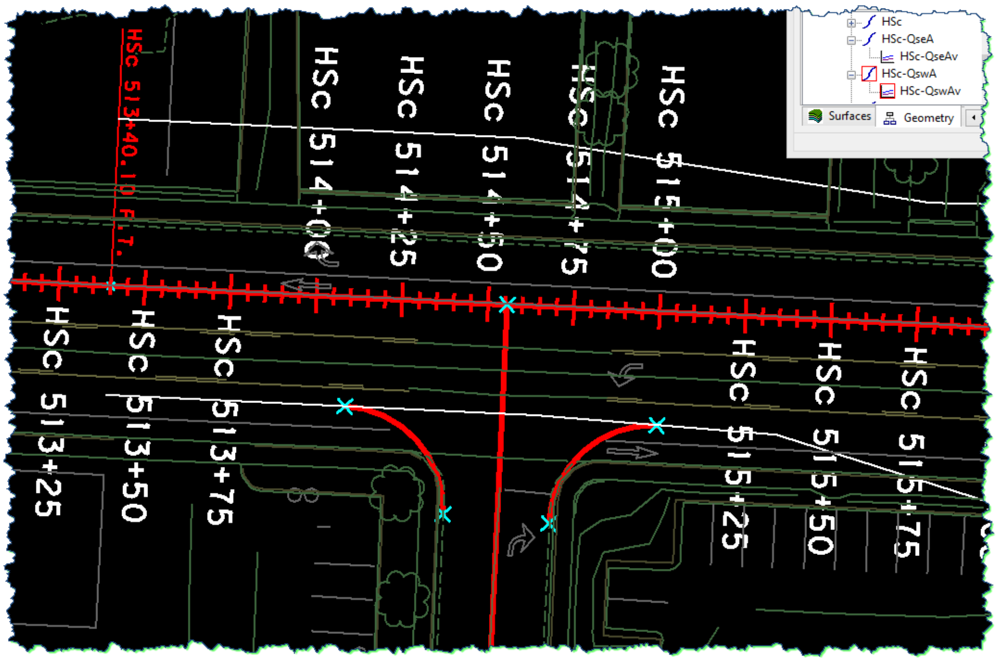
- **Name**: HSc-QswA – SW Quadrant Approach
  - **Width 1** = 31.693 (at Station 514+25 along the primary road)
  - **Width 2** = 15.80 (measured between the approach center and ex. pavement edge)
  - **Radius** = 30 (arbitrarily selected here based on space considerations)
  - Use design cross slope on primary model at the PC (used for **Gradient** on **First Selected Alignment** under **Create Vertical Alignment**)
  - **Surface** = 12345INTER_og (used for **Second Selected Alignment** under **Create Vertical Alignment**)
- Name: HSc-QseA – SE Quadrant Approach
  - **Width 1** = 33.000 (at Station 515+05 along the primary road)
  - **Width 2** = 15.10 (measured between the approach center and ex. pavement edge)
  - **Radius** = 30 (arbitrarily selected here based on space considerations)
  - Use design cross slope on primary model at the PC (used for **Gradient** on **First Selected Alignment** under **Create Vertical Alignment**)
  - **Surface** = 12345INTER_og (used for **Second Selected Alignment** under **Create Vertical Alignment**)



The values shown earlier very likely could be refined, and should be accurate when working on your project. Regardless, the workflow is the same.

3) Verify the alignment creation both horizontally and vertically. Make any modifications as needed based on your project design criteria.

In this module, we will move forward with the workflow using the alignments as just created.

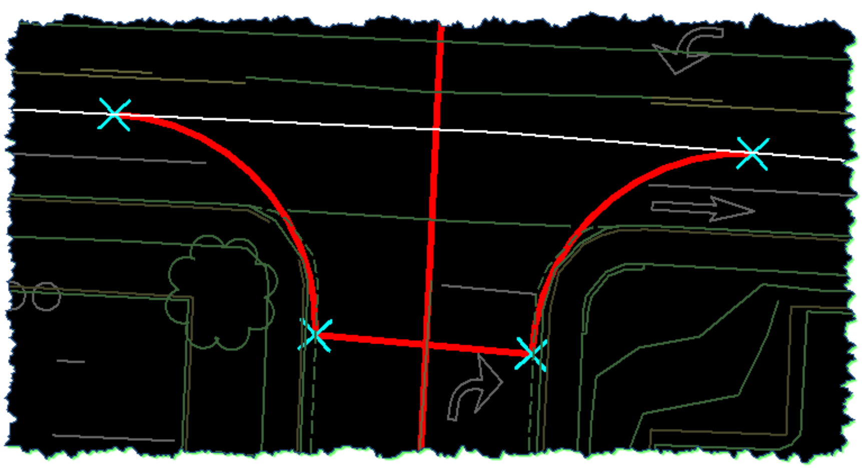


Approach Tie-in Location

An alignment will be created to use as a control for the back of the approach. This can be created as either a surface **Feature** or an alignment. The **POINT CONTROL** can be from the **Surface**, **Geometry**, or based on a **Style**. The exact method is up to you and your comfort.

The geometry can be created both horizontally and vertically. In this example, however, it will only be created horizontally. The vertical control will be addressed a different way.

1) Create a very simple horizontal alignment with two PI points from the PT of the first approach return (**`HSc-QswA`**) to the PT of the other (**`HSc-QseA`**) return (at the back of the approach), and name it **`HSc-LA_Tie`**.



2) For future reference, using some method that you are comfortable with, determine the stationing along the primary road where the approach returns tie to the **EP**.

The primary road stationing that was determined is:

- **514+09.772** at the start of **HSc-QswA**
- **514+39.772** at the end of **HSc-QswA**
- **514+70.672** at the end of **HSc-QseA**
- **515+00.672** at the start of **HSc-QseA**

Confirm that your results are similar.

Overall Modeling Method

Here is the methodology that will be taken to model this area: (Feel free to use the information presented here and add this major approach modeling to the primary roadway. After this overall method is covered, a little more detail will be provided as an aid to lay out the details.)

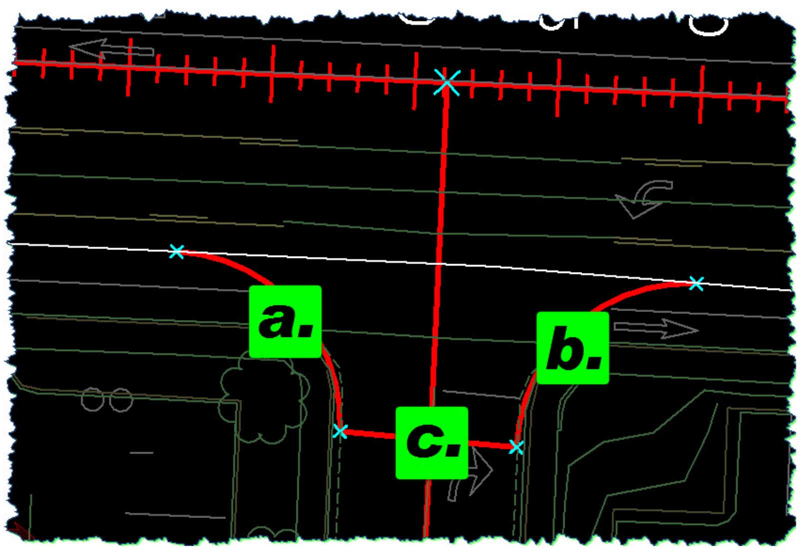
Point Controls

Note that it's important that the **POINT CONTROLS** for the returns be modeled as **Secondary Alignments**. The back edge (**HSc-LA_Tie**), however, doesn't need to be.

a. The southwest return will be added as a **POINT CONTROL** to the primary road, and will be used to control both horizontally and vertically.

b. The southeast return will also be added as a **POINT CONTROL** to the primary road and will be used to control both horizontally and vertically.

c. The back edge of the approach will be the final **POINT CONTROL** used to horizontally locate the back of the grading in this area. Vertically, this location will be controlled by a template **Point Constraint** to project that point to the OG surface using **Project to Surface**.



Templates

This approach only requires the creation of one template; however, in total there will be three new template drops added to the **Corridor**.

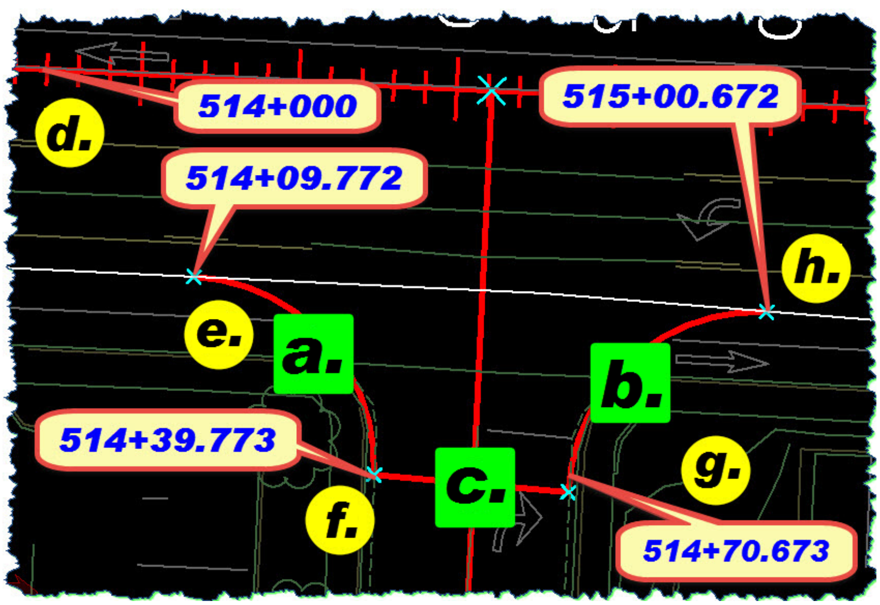
d. A full template drop will be added so that the **Interval** can be densified from **5′** to**2′** around the approach returns.

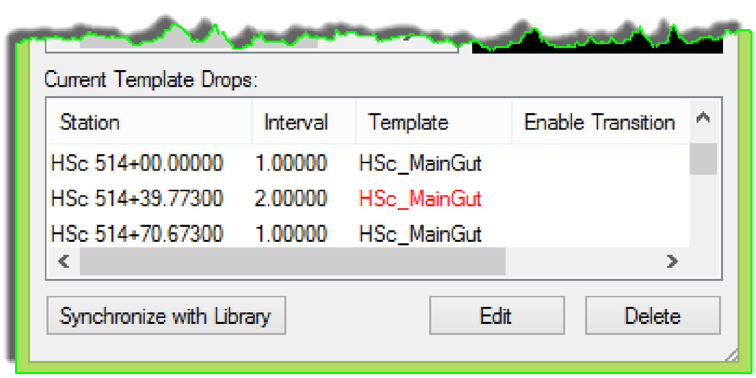
e. The normal full template, continuing from the densification drop, will model around the southwest return along the **POINT CONTROL**.

f. A template will be slightly modified (to remove the C&G, planter, sidewalk, and ECs) and added at the start of the back of the approach and model straight across the back. Vertically, the back **EP_R** will be constrained to match the OG surface. Horizontally, it will travel along the horizontal **POINT CONTROL**.

g. A new drop of a normal full template will be added slightly past the PT of the southeast return and will model around the return along the **POINT CONTROL** to the forward PC.

h. The southeast return **POINT CONTROL** will end and the normal road section modeling will continue.





Key Stations

i. Lastly, **KEY STATIONS** *may* have to be added depending on the modeling interval, template drop locations, and template section changes.

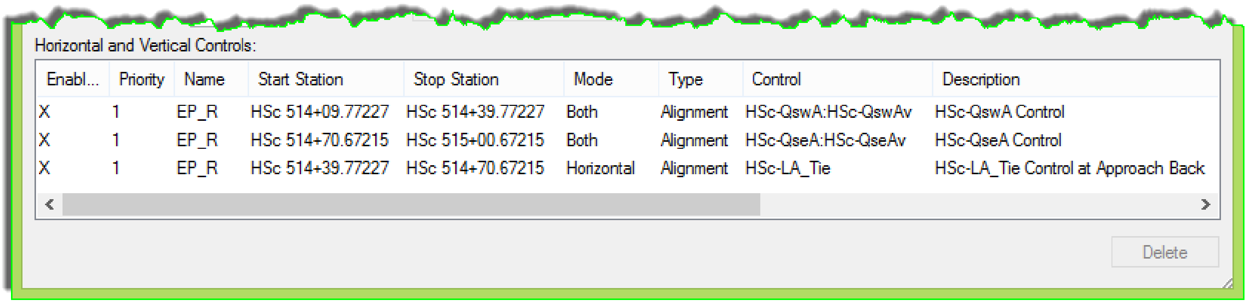
Adding the Point Controls

Whether the **Point Controls** are added first, or the template drops are, is only a matter of availability of the **Template Points** to which the controls will be assigned. If template drops already exist in the corridor that contain the names needed for the **Point Controls**, then they can be added. However, if new templates are introducing new template points that require the controls, then this step would have to wait until those templates are added.

1) Modify the primary road corridor to model the approach by adding **Point Controls** along the primary road to tie the modeling into the approach.

You should have this worked out at this stage, but feel free to refer back to the stationing identified earlier if needed.

- Tie the **`EP_R`** to the SW return horizontal and vertical alignments
  - **Start** / **Stop** stations from the very beginning until the very end
  - Use as **Secondary Alignment**
- Tie the **`EP_R`** to the SE return horizontal and vertical alignments
  - **Start** / **Stop** stations from the very beginning until the very end
  - Use as **Secondary Alignment**
- Tie the **`EP_R`** to the approach **`HSc-LA_Tie`** horizontally only
  - **Start** / **Stop** stations from the exact PT of the SW return to the PT of the SE return



Enabl...	Priority	Name	Start Station	Stop Station	Mode	Type	Control	Description
X	1	EP_R	HSc 514+09.77227	HSc 514+39.77227	Both	Alignment	HSc-QswA:HSc-QswAv	HSc-QswA Control
X	1	EP_R	HSc 514+70.67215	HSc 515+00.67215	Both	Alignment	HSc-QseA:HSc-QseAv	HSc-QseA Control
X	1	EP_R	HSc 514+39.77227	HSc 514+70.67215	Horizontal	Alignment	HSc-LA_Tie	HSc-LA_Tie Control at Approach Back

Template Modification

At this stage, you should be well aware that you could work with new templates in the ITL or in the IRD by copying either existing templates or existing entries. This is a choice where you will have to develop your own practices, since the choice is mainly administrative.

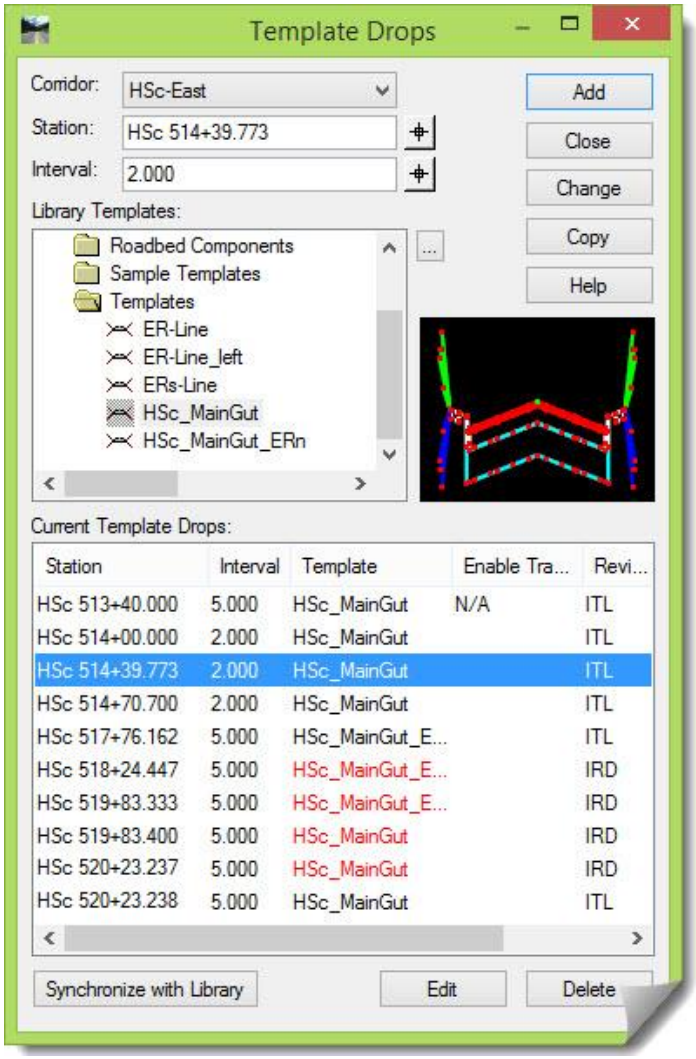
1) In the **Roadway Designer**, verify that the active **Corridor** is **`HSc-East`**, and open the **Template Drops** dialog box.
2) Select the first entry in the **Current Template Drops**; enter a **Station** of **`514+00.00`**, an **Interval** of **`1.00`** and then [**Copy**].
3) [**Copy**] that new **Template Drop** to Station **`514+70.6730`**.

These two new drops are identical entries of the full roadway section that will carry from that station location forward.

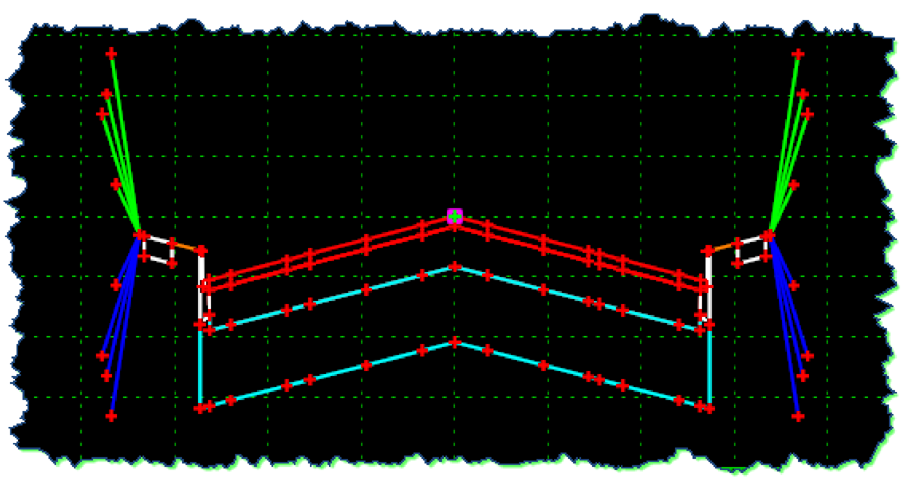
Next, the modified template drop will be created for the back edge of the approach.

4) Once again, select the first template entry; enter a **Station** of **514+39.773**, an **Interval** of **2.00** and then [**Copy**].

This new entry will be modified for the section between the two approach returns.

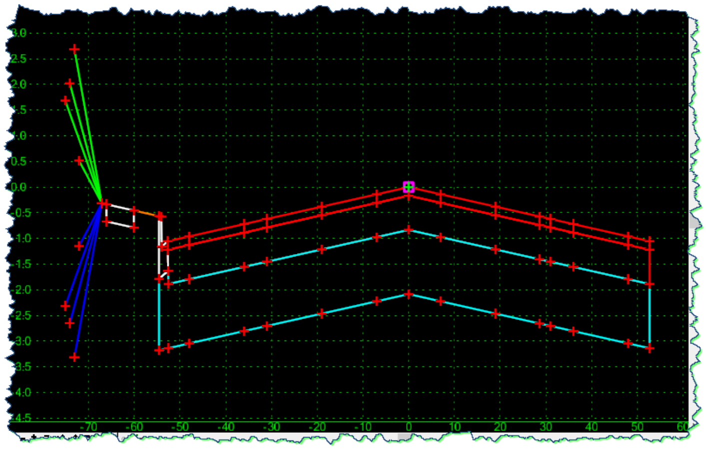


5) Select the entry that was just added (**514+39.773**) and [**Edit**].



6) Remove the ECs, sidewalk, planter, and curb & gutter components from the right side, as well as making sure that those outer points are all horizontally lined up as was done in the earlier scenarios. Don't close the editing window on this, there is more to follow.

The revised template should look like this:



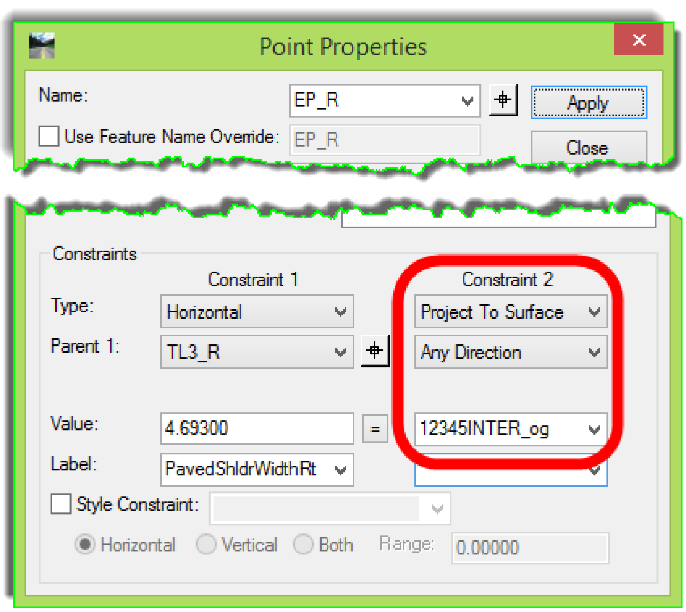
Based on the plan described earlier, the **EP_R** point on this template will be assigned a **POINT CONTROL** to tie it into the back of the approach.

Depending on exactly how you want this grading to work, and what primary roadway edges you need, you may want to add another road bed component onto the end of this section and tie the **POINT CONTROL** to that point instead.

This example will move forward with connecting the **EP_R** here to the back of the approach, horizontally with a **POINT CONTROL**, and vertically by adjusting the **Point Constraint** in the template.

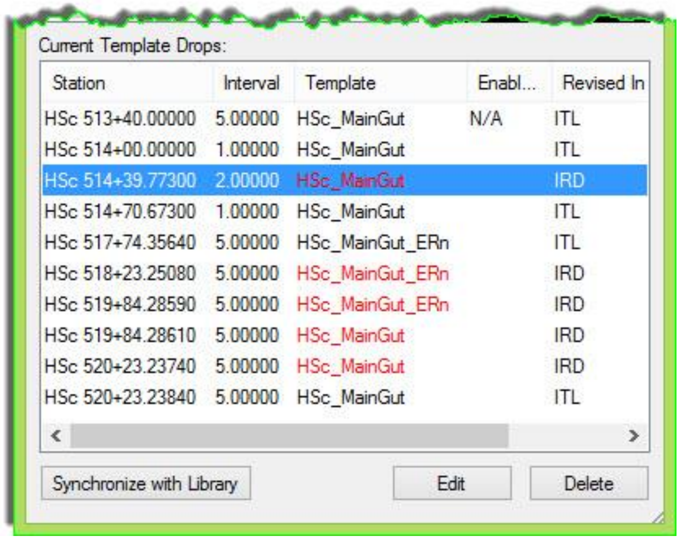
7) Edit the **EP_R** template point and assign a **Project To Surface** constraint on this point by replacing the **Slope Constraint**.

You can also decide to either define the **Value** as the **OG** surface, or set it to **<Active>**.



8) [**OK**] when you are done with that edit.

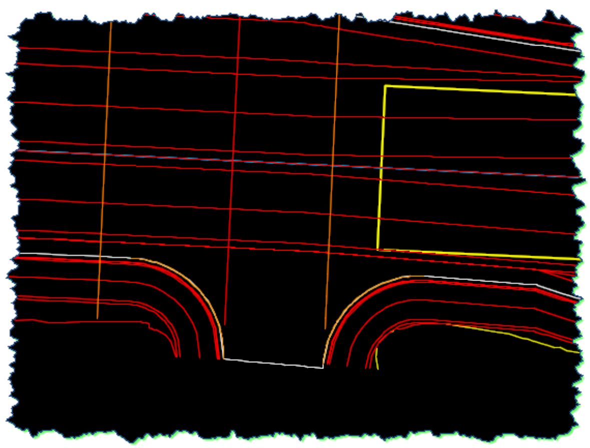
The **Current Template Drops** entry should now be reflecting the IRD location and the modified template.



Station	Interval	Template	Enabl...	Revised In
HSc 513+40.00000	5.00000	HSc_MainGut	N/A	ITL
HSc 514+00.00000	1.00000	HSc_MainGut		ITL
HSc 514+39.77300	2.00000	HSc_MainGut		IRD
HSc 514+70.67300	1.00000	HSc_MainGut		ITL
HSc 517+74.35640	5.00000	HSc_MainGut_ERn		ITL
HSc 518+23.25080	5.00000	HSc_MainGut_ERn		IRD
HSc 519+84.28590	5.00000	HSc_MainGut_ERn		IRD
HSc 519+84.28610	5.00000	HSc_MainGut		IRD
HSc 520+23.23740	5.00000	HSc_MainGut		IRD
HSc 520+23.23840	5.00000	HSc_MainGut		ITL

9) [**Close**] the **Template Drops** and [**Process All**] to review the results.

The plan view window of the **Roadway Designer** should show that the approach breaklines look reasonable in that area of the model.



As mentioned earlier, in this scenario the **EP_R** was pulled around the west return toward the back of the approach, along the back of the approach, and then around the east return to resume its normal position at the end of the east return.

An alternative method that would leave the **EP_R** in its normal position through the approach area could be done like this:

a. Modify the primary road template in that area to add a pavement section component, as was included in the return templates that were reviewed in **Scenario 1**. Call this new outer point something like **EP2_R**, and establish its width to **0.01′** as a horizontal constraint from **EP_R** to **EP2_R**. Then constrain the back point **EP2_R** to the surface vertically, like was done previously in this section with **EP_R**. (The vertical point control on the returns will override the vertical constraint.)

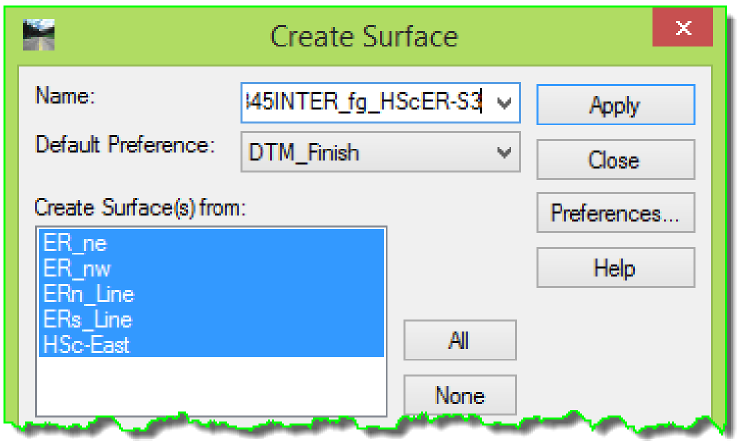
b. Tie **EP2_R** to the **SW** & **SE** return horizontal and vertical alignments

c. Tie **EP2_R** to **HSc-LA_Tie** horizontally only

d. This would model the primary road like this:

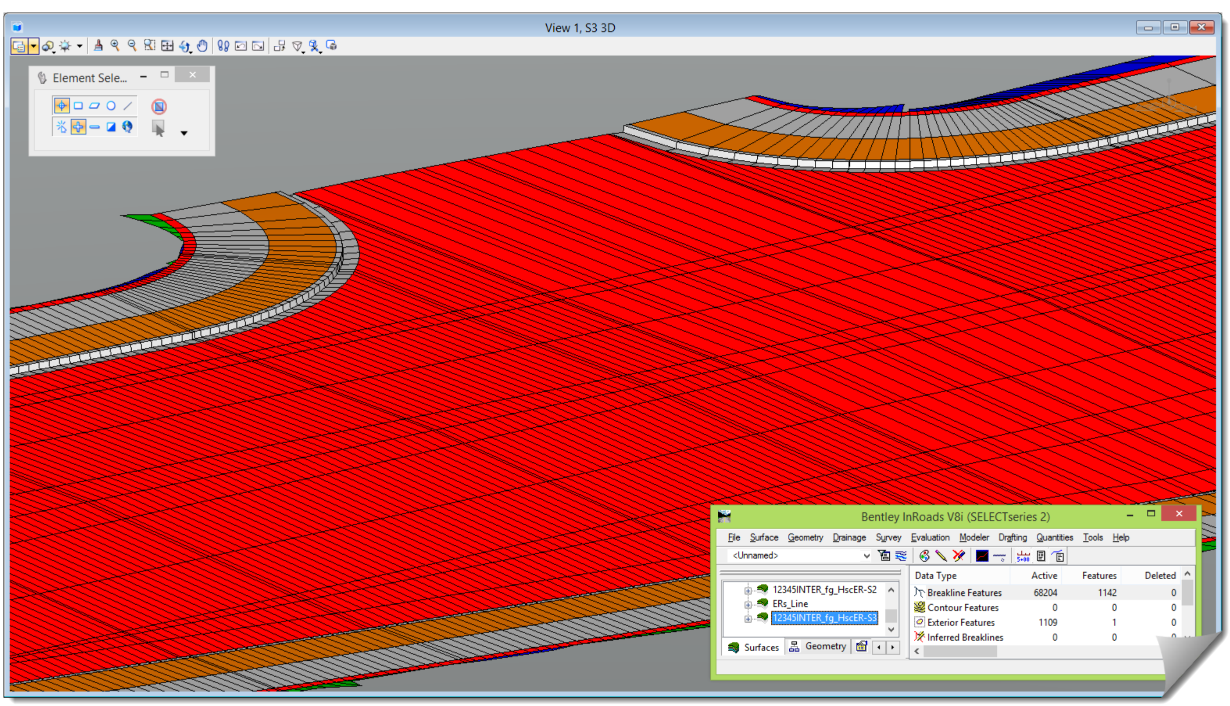
- Model normally up to the southwest return PC
- Then it will model the **EP_R** and gradually introduce the new pavement section as **EP2_R** rides along the southwest return to its PT
- Then **EP2_R** will trace along the original ground along the **LA_Tie** horizontal path to the PT of the southeast return
- Then **EP2_R** will ride along the southeast return and converge with the primary road **EP** as it traces around the return until it ends at the PC of the return
- Then it restarts the normal primary road section

10) With the current corridors, create a surface with the settings that have been used throughout this module, called **12345INTER_fg_HScER-S3**.



11) [**Close**] and [**Save**] the **Roadway Designer** and view the surface results.

12) [**Save**] the design surface.



OTHER DETAILS

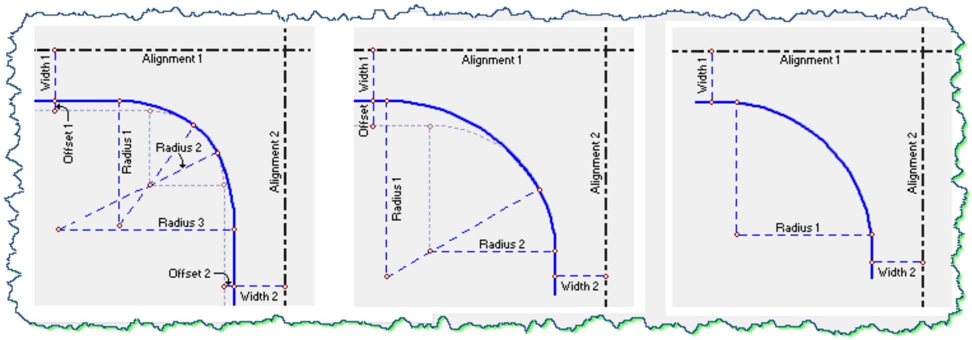
To wrap up this module, a few topics will be revisited, and some food for thought will be mentioned.

Modeling to the Next Level

Is this it? No, there are more details to consider in a broad topic like "Intersections". The next stage of intersection refinement will require a higher level of understanding of certain topics and even more advanced techniques.

Return Geometry

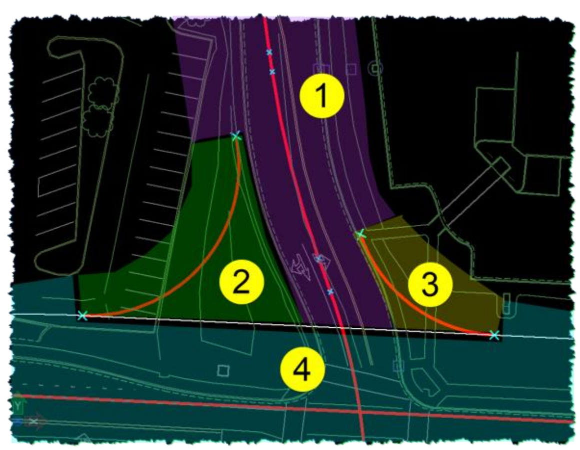
The **MULTICENTER CURVE** tool is a good tool for creating returns very quickly for both the horizontal and vertical geometry. This tool can lay out some sophisticated geometry; however, it cannot and will not apply to all returns on all projects.



This tool was never intended to be a 'solve all' operation, but simply an aide to the user when it applied. There will be very few times you will be able to use the vertical alignment produced by this tool without modification. There will also be times when you should simply create only the horizontal alignment with this tool, and lay out the vertical alignment with the vertical design tools. There will even be times when this tool is impractical, and both the horizontal and vertical alignments will have to be laid out using traditional layout methods.

Just keep this in mind, and refer back to the earlier *Creating Curve Returns* section for the tip on how this tool would work if the roadway is superelevated.

Template refinements



Take Scenario 1 for example. Other corridor configurations could be used here depending on your design criteria. For example, if it were desired that the secondary road travel lanes carry through to the primary road, the corridors could take on the general configuration shown here. Of course, the templates would have to be modified to hold onto whatever was influencing this modeling arrangement.

As an added note, the template drops of 1' used in Scenario 3 may result in undesirable chord distances along the return. This should be checked after modeling, and if found unacceptable, may require some further adjustments. One way to overcome this is using the **Densify using Chord Height Tolerance** when creating the surface.

Template Modifications

As shown by the workflows in **Scenario 1** versus **Scenario 2**, template modifications can be either done in the ITL and then added to the IRD, or done in the IRD directly.

Advantages / Disadvantages / Commentary:

- Creating templates and editing them in the ITL provides the ability to name each template uniquely. Working directly with templates in the IRD does not allow this, although the **Description** can be revised to capture the template variations, and that may be sufficient.
- Working directly in the IRD is faster, but requires a higher level of personal modification and edit tracking.
- The IRD corridors do not require all of its templates to come from the same template library. 'Disconnecting' the templates from the ITL opens the door to utilizing templates from multiple ITLs and relieves the pressure to have a project-specific ITL.
- In an environment where multiple people are working on the IRD Corridors (at different times of course), it may be challenging for each other to know what has been done to the templates in the IRD, and whether specific edits have been made or not.
- Changes can be made to the templates in the IRD during the project, and then at the appropriate time, can be copied back into the ITL and then **Synchronized with Library** in the IRD moving forward. Depending on the size of the corridor, this can be a challenge and potentially result in mistakes. There is also a probability that you will want to rename the templates after copying it to the ITL, and may have to reconnect many of your corridor template drops to the new templates in the ITL.

Point Controls

In Scenario 1, the returns of the intersection were modeled with only a few **POINT CONTROLS** – one along the primary road EP and one along the secondary road centerline. This modeling configuration could be refined further by applying additional **POINT CONTROLS** to address the loss of lane integrity that occurs in its current corridor configuration.

Parametric Constraints

The strength of **PARAMETRIC CONSTRAINTS** should be evident if the earlier modules have been done. This same strength can be applied at certain locations in this module if some thought was put towards it.

Display Rules

DISPLAY RULES add a very powerful capability to reduce template drops within a corridor, allowing the software to apply a curb and gutter or sidewalk when needed. **DISPLAY RULES** can virtually eliminate the need for copying templates and manually removing unwanted components during the development and refinement stage. The power of **DISPLAY RULES** is balanced by the level of template configuration and the user's ability to comprehend what is happening during the application of the **DISPLAY RULES** within the model. This technique was introduced in Scenario 1, but could be used much more extensively during intersection modeling.

This could be an entire module on its own.

Modeling Precision

A few things need to be mentioned about modeling precision.

Decimal Precision

In this particular module, you should have noticed that some of the entries were taken out to three decimal places, some out to four places, and in some cases even further. This level of entry is not an explicit direction to use this decimal precision and was simply a decision made during the creation of this sample project. The real driver of the precision required in defining the corridor modeling is really the resulting surface. There will be times when a higher precision value is needed to ensure gaps are closed and triangulation is contained between the modeling intervals used.

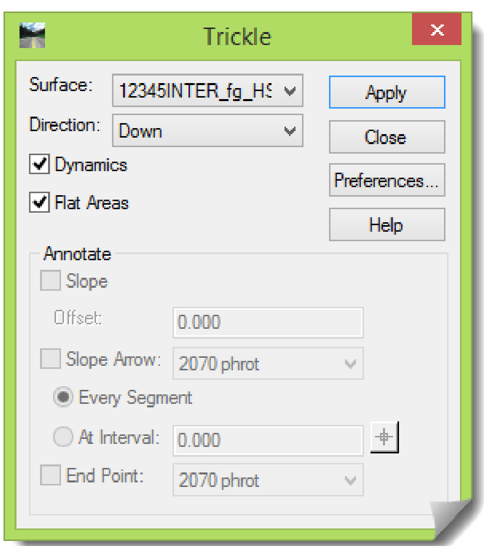
For instance, if the station of the end of a return used for modeling in an intersection was found to be exactly `61+19.57900`, you would not be able to place a modeling drop coinciding with station `61+19.58`. Why? Because the return doesn't exist at that station, it's past the end. Sometimes rounding the values up will work against you because mathematically, the values may not coincide with the control alignment (or feature). If this example were indicating the stationing of the start of a control, then rounding up would be acceptable because that stationing could still be found on that alignment.

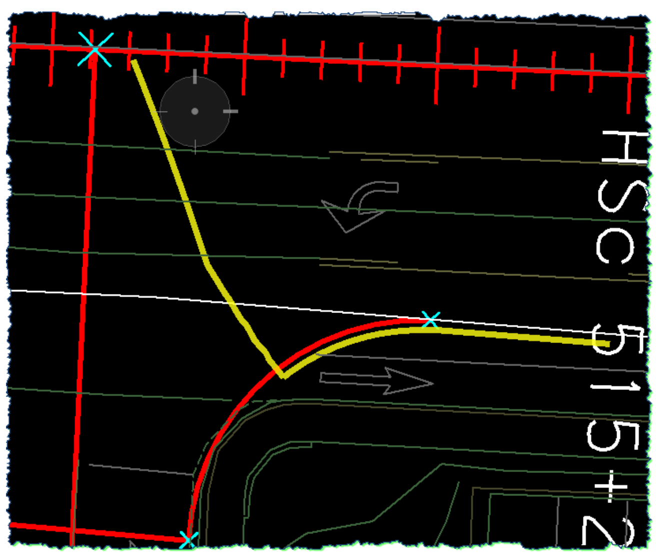
Pavement / Subgrade Matching

Sometimes there is a need to transition the structural section from a secondary road to the depth found on a primary road. The use of **PARAMETRIC CONSTRAINTS** and their associated **Label** is a valid technique to control this type of linear section transition. In other cases, **POINT CONTROLS** can be strategically applied to transition template layers. A third option is to use the simplicity of another template drop.

Trickle

It was implied in several locations that drainage should be considered in the design. The **TRICKLE** tool found under ***EVALUATION > HYDROLOGY AND HYDRAULICS*** is a fantastic tool to assess drainage patterns on your surface model. The value of this tool is greatly expanded when combined surfaces, such as the ones covered in this module, are available.





Target Aliasing / Corridor Clipping

TARGET ALIASING and the related **CORRIDOR CLIPPING** were very briefly mentioned at the start of this module, but were not taken further.

The use of this functionality comes into play when corridors overlap one another. It is very effective when corridors are running adjacent to each other and the End Conditions, typically targeting the OG, have the capability to target the adjacent EC solution if appropriate.

These topics warrant additional research and have potential future applications; however, they were not needed using the techniques presented in this module.

Roadway Designer Options

When running the **ROADWAY DESIGNER** corridor processing, a mention has to be made to be aware of the **ROADWAY DESIGNER OPTIONS**.

These settings not only provide benefit in terms of feedback, but they also govern how models are processed. The **Include Critical Sections** area of the dialog box is very important to the sections modeled during the **Corridor** processing and should be understood.

Conclusion

Congratulations, you have completed the Intersection module and have gained a deeper insight into the creation of complete surface models that you may not have had before.

We leave you with our encouraging final thought – Do these modules with an attitude of application. Study them with the viewpoint that you are going to apply these new skills on your current or future project. Look into and beyond the exercise steps and motivate yourself to momentarily pause and consider past, present and future projects and how this information could be put into practice.