

Workflow IR 18 CAD Data checking for Quality Assurance Guide

*Colorado Department of Transportation
CADD Manager's Office*

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Introduction

Quality assurance is a way of preventing mistakes and avoiding problems when delivering a product to customers. In this case, the product is an InRoads digital terrain model of a proposed construction project. The procedures below are designed to familiarize the designer with the data that is received at each stage of the design process, identify potential issues with the data, locate areas of special concern within the project limits, and review produced data prior to its being handed off to the next phase of design. The idea being to eliminate, as much as possible, passing on errors or design flaws from one stage of the project to the next.

Quality assurance is especially important when project deliverables are electronic data files, such as ALG (geometry), DTM (terrain models), DGN/DWG (CADD drawings), and/or LandXML (geometry, terrain model, or cross section data translated to LandXML format). In the event that a project is a candidate for 3D engineered modelling for highway construction, it is imperative that they represent the intended design accurately because they can be used for Automated Machine Grading (AMG). The result of following these quality assurance procedures along with the Specifications [DB 2016-4](#) (refer to PDM 8-33 to 36) is a 3D engineered model for construction that is ready for use on the construction site.

Note: The creation of LandXML files is covered in [Workflow IR 17 – Exporting A LandXML File](#)

Outline for InRoads Quality Assurance

1. **Initial Data Review** - The initial evaluation process is used to determine how a project will be designed. It is also used as a final check of the existing ground surface to ensure that there are no busts in the data and to identify areas of special concern. The following items are used for the initial surface review:
 - a. Review existing surface Properties
 - b. Review existing surface Topo
 - c. Review existing surface Contours
 - d. Review existing cross sections
2. **Setting Design Parameters and Reviewing Design Data** – This includes various settings that control where design data is generated and how data is displayed in MicroStation. Each task in creating design data should be reviewed as it is completed so that the next task will start with the most accurate data possible.
 - a. Geometry Review
 - i. Review Horizontal Geometry
 1. Enter Event Points for areas of special concern.
 - ii. Reviewing Vertical Geometry
 1. Profile Exaggeration
 2. Annotating Profiles

- b. Roadway Designer Set up and Review
 - i. Template Drop Interval
 - ii. Changing Templates
 - iii. Using Event Points and other important stations
 - a. Horizontal and Vertical Cardinal Points (PC, PT,PVC,PVT, etc.)
 - b. Drainage structure crossings
 - c. Driveways
 - d. Median crossovers
 - e. Intersections
 - f. Pavement changes
 - g. Inlets and manholes

Note: Important locations could be stored as “Key Stations” within the *.ird file in Roadway Designer. However, storing them as “Event Points” within the *.alg file makes them available to team members without having to load the *.ird file.

- iv. Setting up and reading Roadway Designer displays
- v. Review Component Quantities

3. Creating and Reviewing the Design Surface Model -

- a. Set up the Create Surface command
- b. Review design surface Properties
- c. Review design surface Contours
- d. Review design surface Topo

4. Comparing Existing Surface and Design Models Data – Design data should be compared to the existing surface data and design criteria at the completion of each design step to ensure that the most efficient design is being developed.

- a. Cross Section set-up
- b. End Area Volume set-up
- c. Generating Triangle Volumes
- d. Comparing Triangle Volumes to End Area Volumes
- e. Using Mass-Haul Diagrams

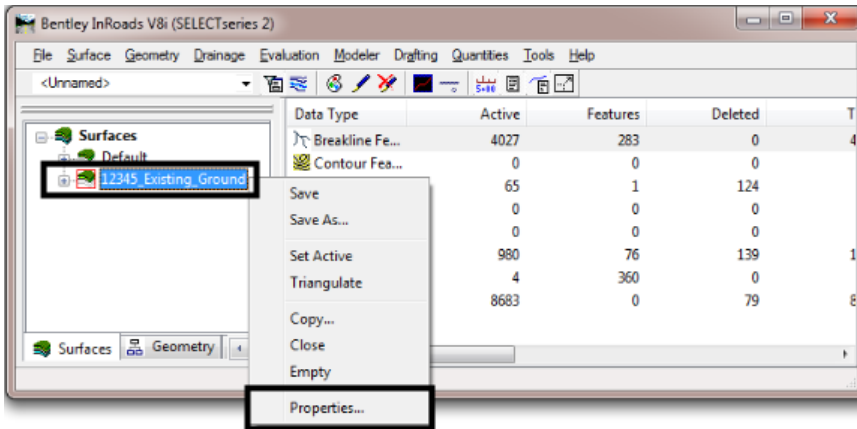
1. Initial Data Review

The designer should review the existing ground dtm upon receipt. This is so that the designer can become acquainted with the terrain and to verify that there are no errors in the surface. This review should include reviewing the Surface Properties and reviewing contours of the surface.

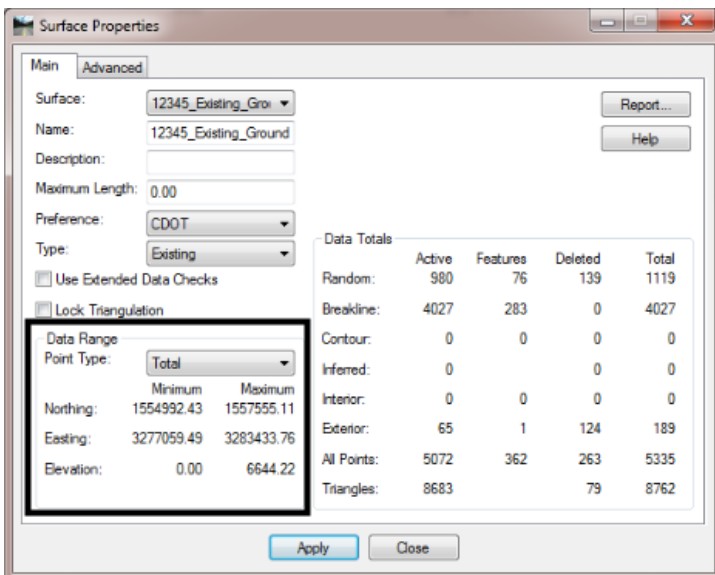
a. Surface Properties

The Surface Properties dialog box contains general information about the selected surface such as the surface type, number and type of features within the surface, data ranges, etc. To review the Surface Properties:

1. Right click on the surface name in the InRoads Explorer and select **Properties** from the list.

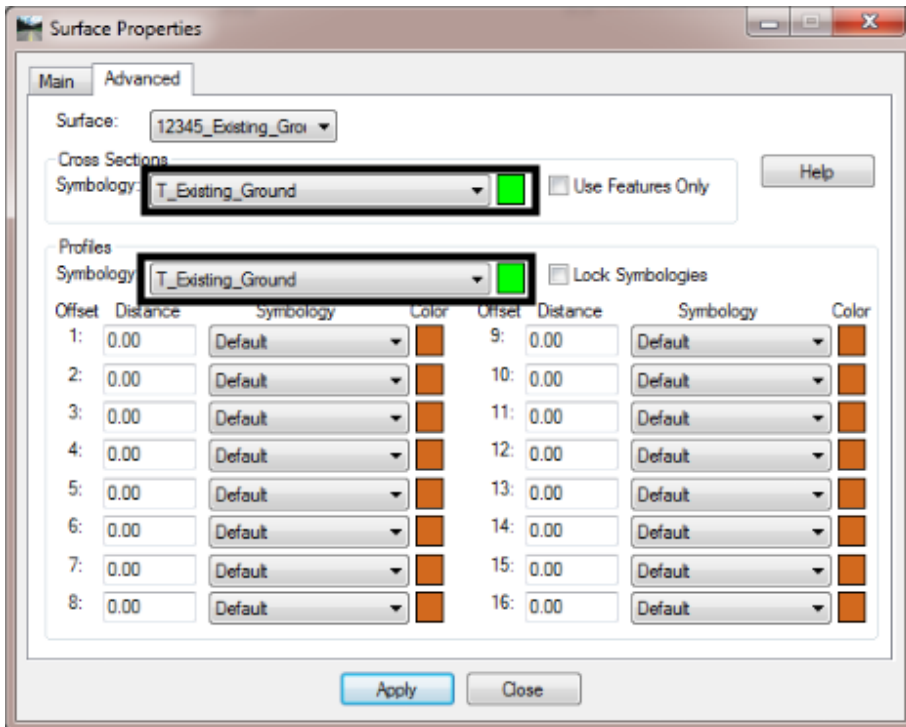


2. In the **Surface Properties** dialog box, review the **Data Range** area. Look for entries that seem abnormal for the area of the project. The most common and easily recognizable issue is a zero minimum elevation.



Just because there is elevation data at zero does not necessarily mean a bust in the survey. Untriangulated data stored in the surface at a zero elevation will not affect the triangles above. However, seeing a zero elevation should prompt additional investigation to determine if the data is valid or not.

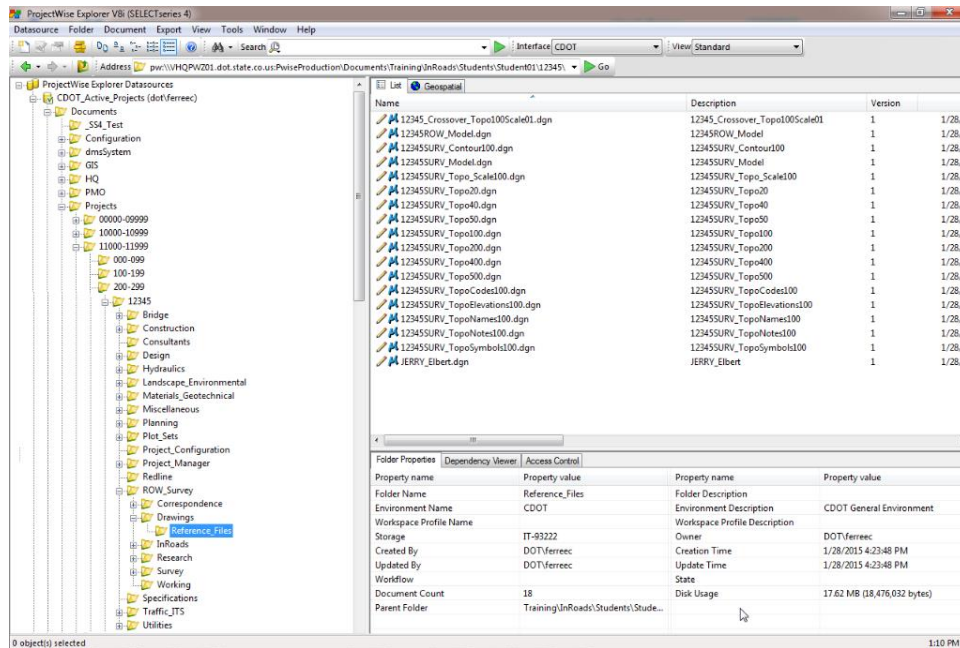
1. Left click on the **Advanced** tab. The **Cross Sections** and **Profiles Symbology** should be set to **T_Existing_Ground**. This symbology causes the existing ground to be displayed as a green dashed line (the CDOT standard) in cross sections and profiles. If the symbology is set incorrectly, inform the surveyor so that it can be reset.



2. Left click **Close** to dismiss the dialog box.

b. Review existing surface Topo

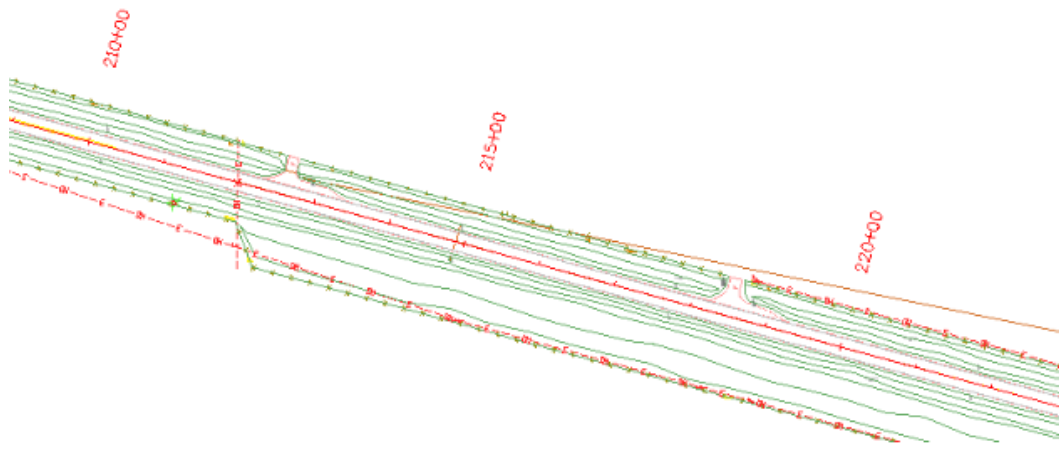
A MicroStation file of the surveyed topo can be found in the \ROW_Survey\Drawings\Reference_Files folder under the project directory in ProjectWise. The illustration below shows the path to the survey topo file in a sample project.



There may be several versions of the topo file in this folder. Because of the way that data is written from the fieldbook, a version is created for each plan sheet scale.

Open the JPC#SURV_Topo_Scale##.dgn file read only so that no inadvertent changes are made. Looking at the topo, items like right of way, utilities, drainage structures, and driveways can be identified. Review the data with an eye towards items that can and/or will influence the design such as existing pavement widths, Drainage structure and utility crossings, right of way, buildings, guardrail, pedestrian paths, environmental sites, signage, and other structures near the proposed roadway, etc.

Generally, survey data is collected in a narrow corridor along the path of proposed construction. However, having a larger view of the area surrounding the construction site can be beneficial. This can be obtained through the use of aerial photographs. The top illustration below shows the surveyed data of a project. The bottom illustration shows the same data overlaid onto an aerial photo.



Survey data only

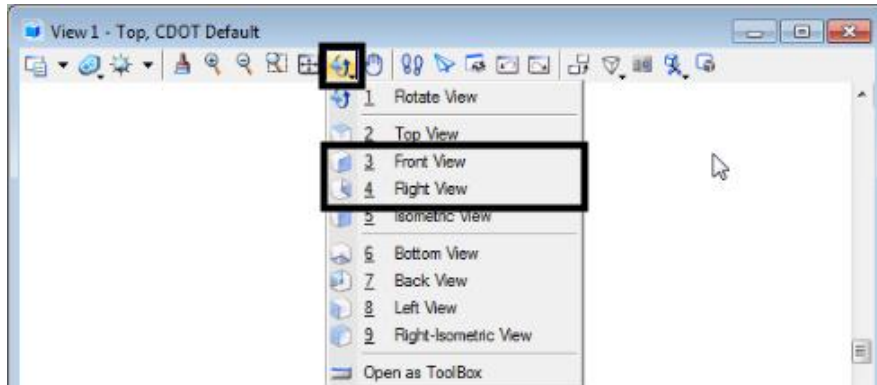


Survey data overlaid on aerial photo

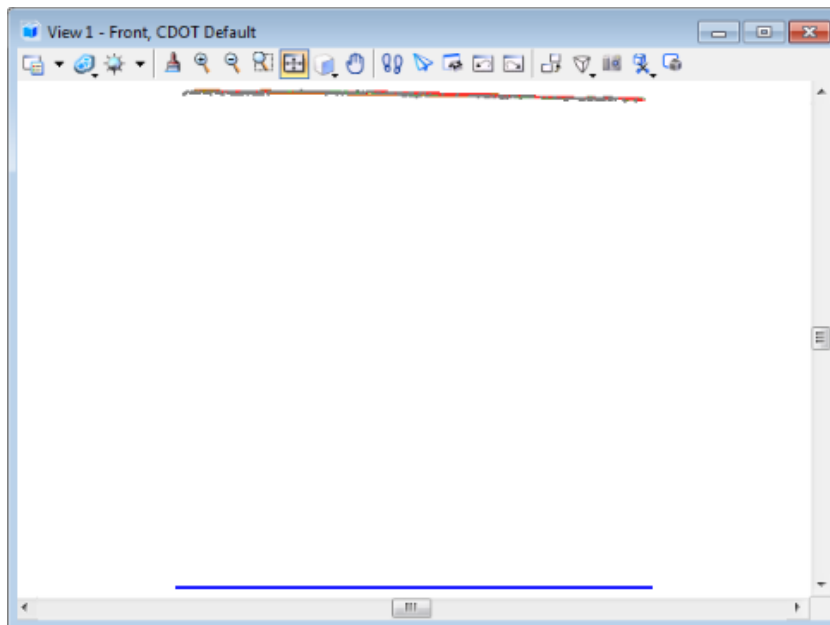
As can be seen in the two illustrations, items of interest show up in the photo that are not represented in the survey data. CDOT has an archive of aerial photographs that cover the entire state. Refer to the workflow [Workflow MS 12 - Accessing Imagery Files](#) to access and copy photos from the archive to the project folder.

Rotating the view in MicroStation can also show large elevation differences in surface data.

- Using the **View Controls**, select **Rotate View > Front View** (or **Right View**)



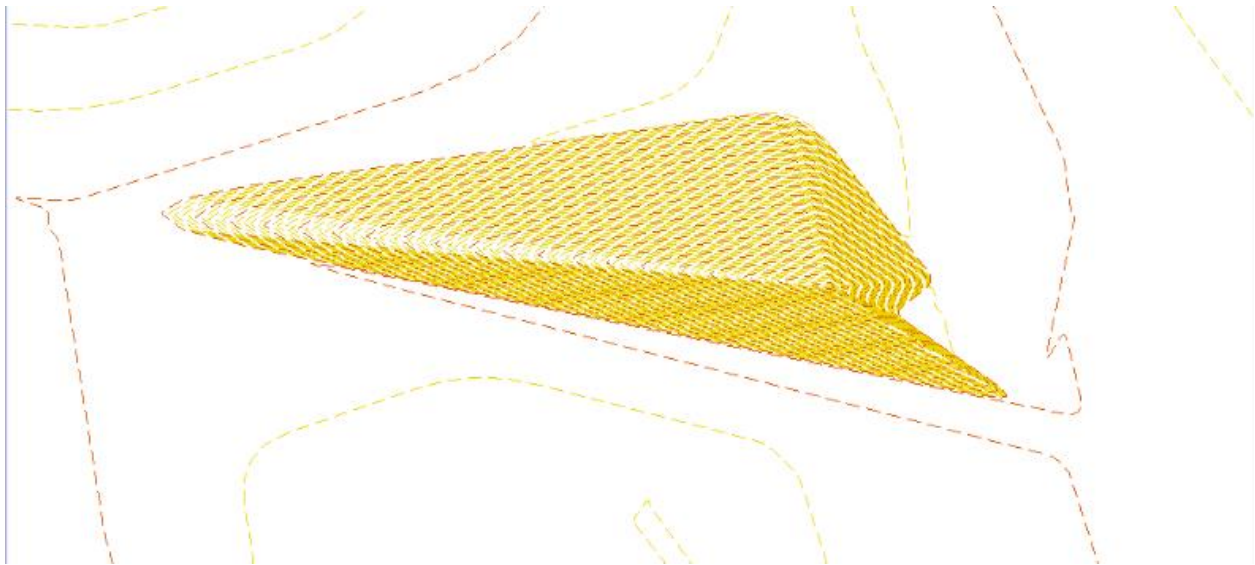
- Select **Fit View**. This fits all the data within the file into the view. The rotation shows the Z axis (elevation) from top to bottom. The illustration below shows data with a large variance in elevation.



Remember to rotate the view back to the **Top View** when the review is completed.

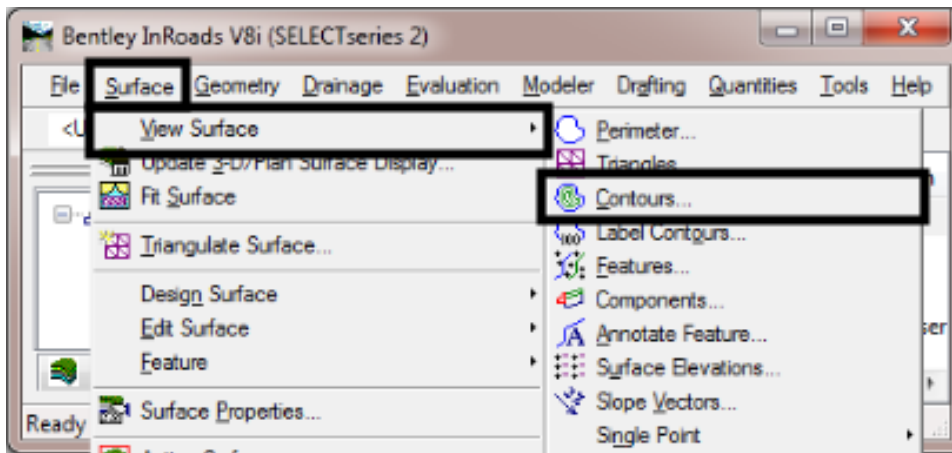
c. Reviewing Contours

Reviewing contours of the existing surface will readily show if zero elevation data in the surface is affecting the triangulated model. It can also indicate other anomalies that are not apparent in the surface properties. Surface anomalies will generally appear as a group of densely packed concentric contours.

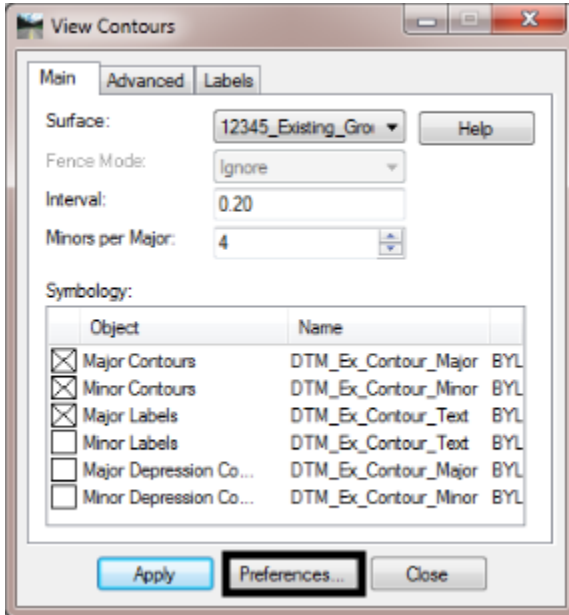


To display contours of the existing ground surface:

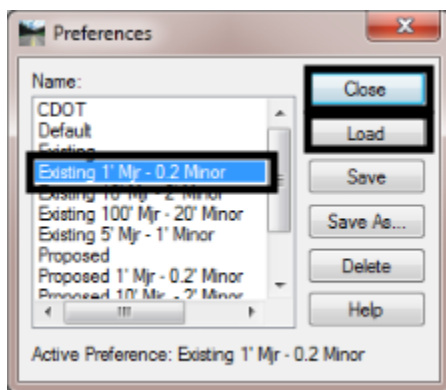
1. From the InRoads menu bar, select **Surface > View Surface > Contours**. This displays the **View Contours** dialog box.



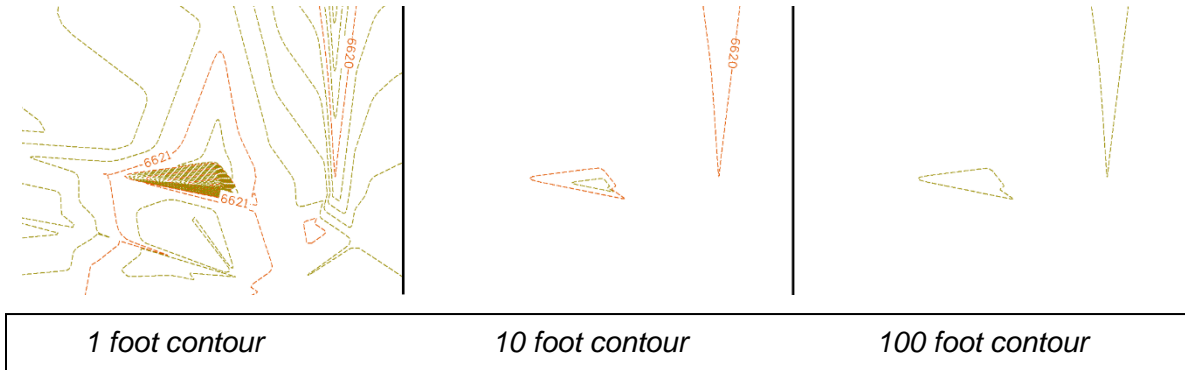
- In the **View Contours** dialog box, left click the **Preferences** button. This displays the **Preferences** dialog box. Preferences are used to determine how the contours are displayed in MicroStation.



- Highlight the desired preference from the list then left click the **Load** button followed by the **Close** button.



Using a small interval makes surface anomalies show up better, though it will increase processing time. The illustrations below show the same area of a surface that contains a shot with a 5 foot elevation bust. The major intervals used are (from left to right); 1', 10', 100'. Notice how much easier the anomaly is to see in the left illustration.



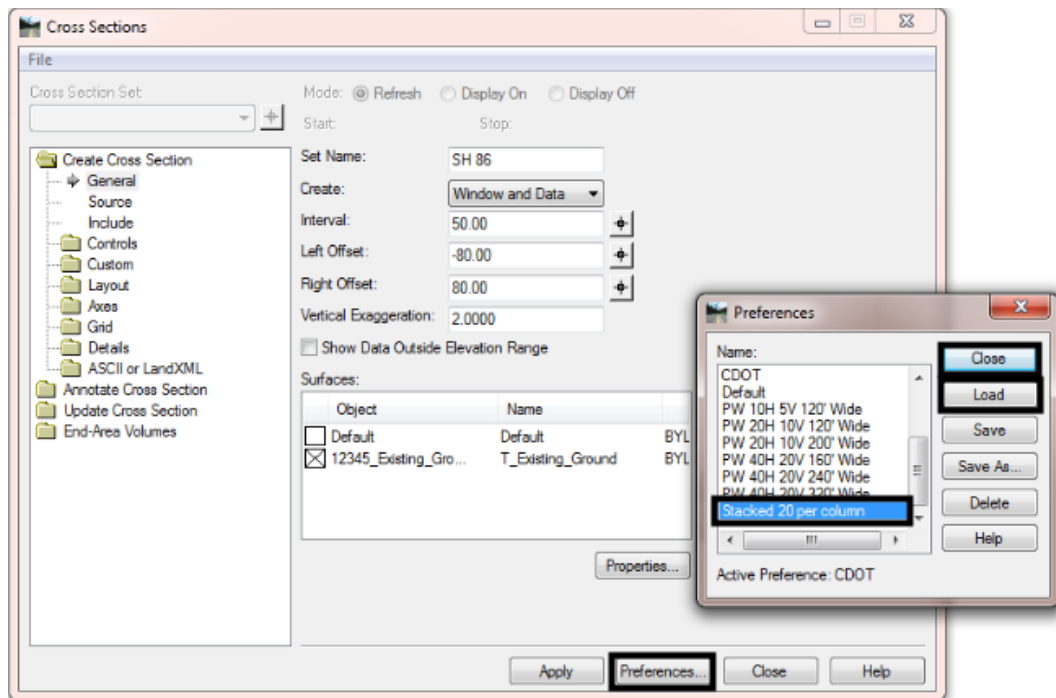
Any questions regarding the existing ground surface should be referred to the surveyor responsible for the data.

d. Creating Cross Sections

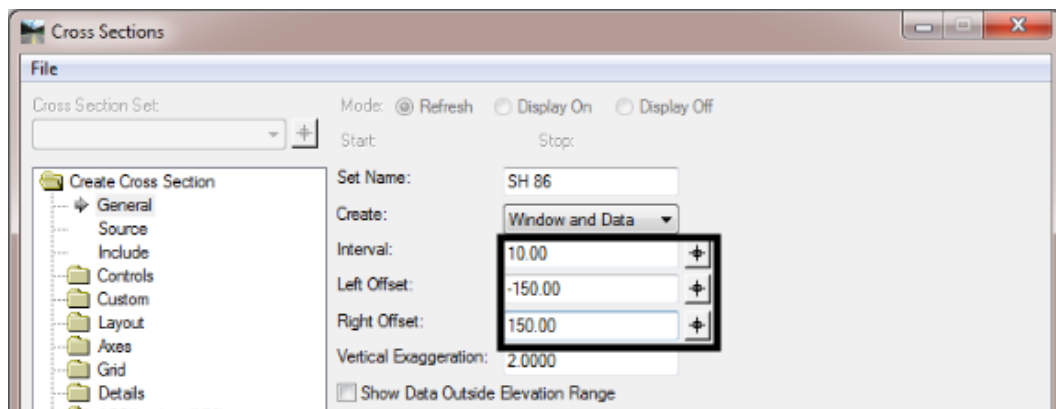
Reviewing cross sections of the existing surface is another way to verify the data. They can also be used to determine various aspects of the surface, such as the side slope value on existing roads.

1. Select **Evaluation > Cross Section > Cross Sections** from the InRoads bar menu. This displays the **Cross Sections** dialog box.
2. From the **Cross Sections** dialog box, left click the **Preferences** button. This displays the **Preferences** dialog box that is associated with Cross Sections.
3. From the **Preferences** dialog box, highlight the desired preference and left click **Load**. Because these cross sections are for review only it is suggested to use the **Stacked 20 per column** preference.

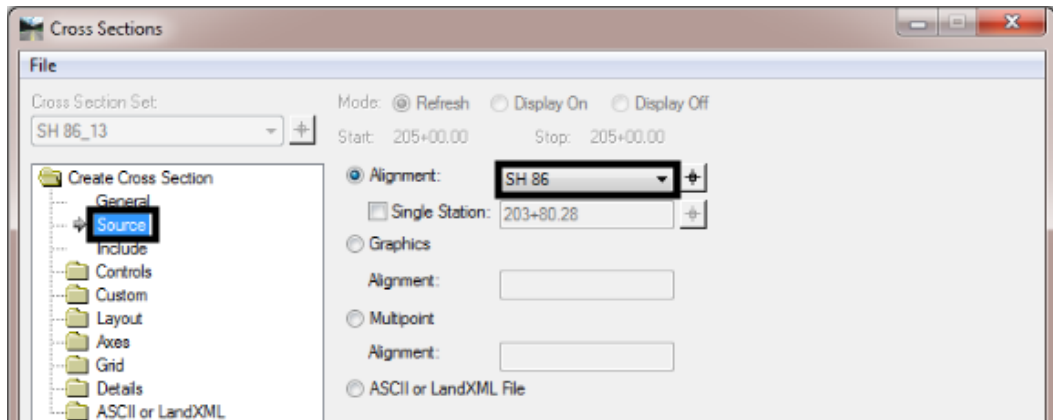
- Left click **Close** to dismiss the **Preferences** dialog box.



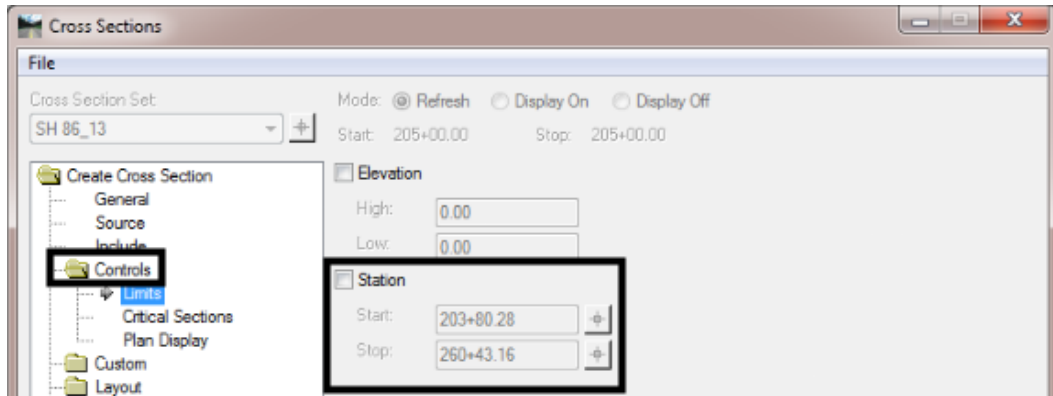
- Set the **Interval** to the desired value. **10** is the standard template drop interval and can be used for this review.
- Set the **Left Offset** and **Right Offset** values to ensure that the entire width of the design area is visible within the cross section window.



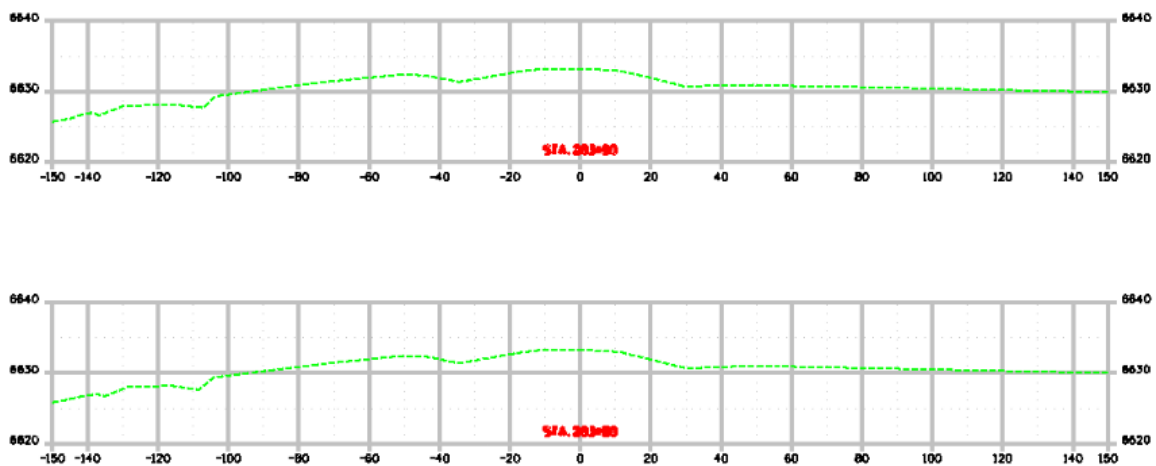
7. Select the **Source** leaf and verify that the correct alignment is selected.



8. Expand the **Controls** folder. Set the Limits as needed.

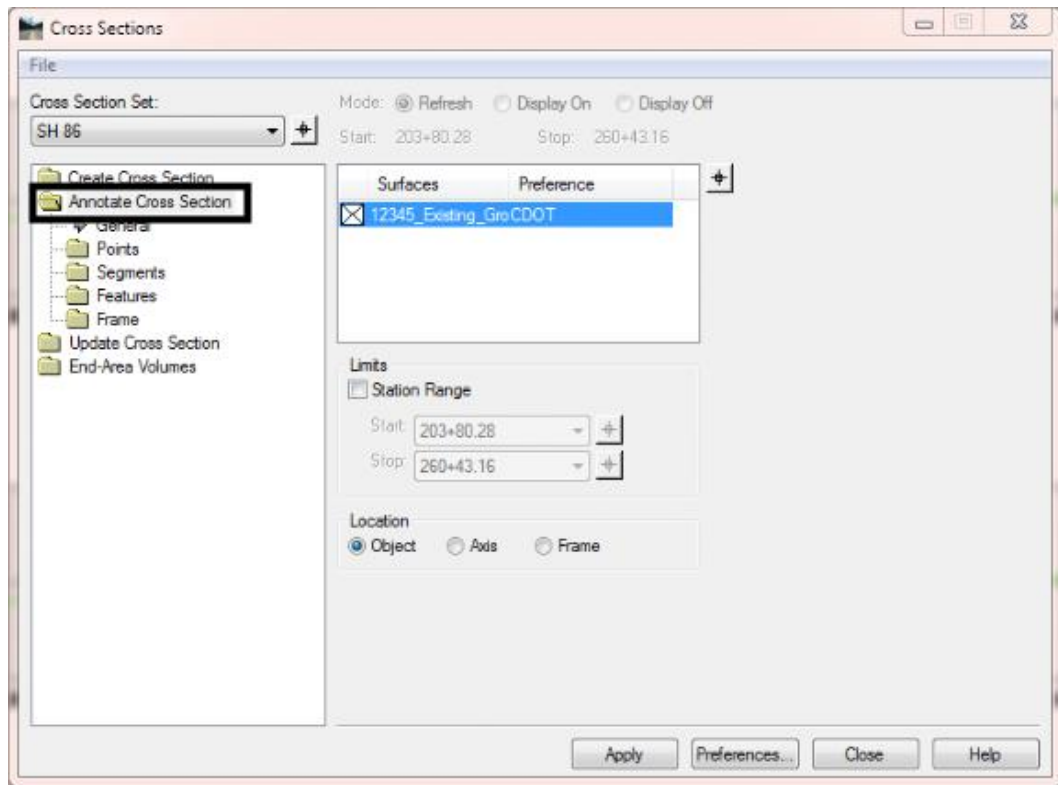


9. Left click the **Apply** button then left click the location for the cross sections. This creates a cross section set. Below is an example of what a cross section will look like.

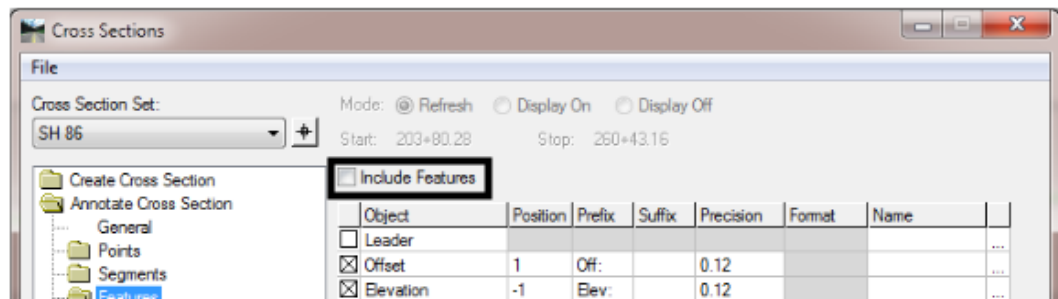
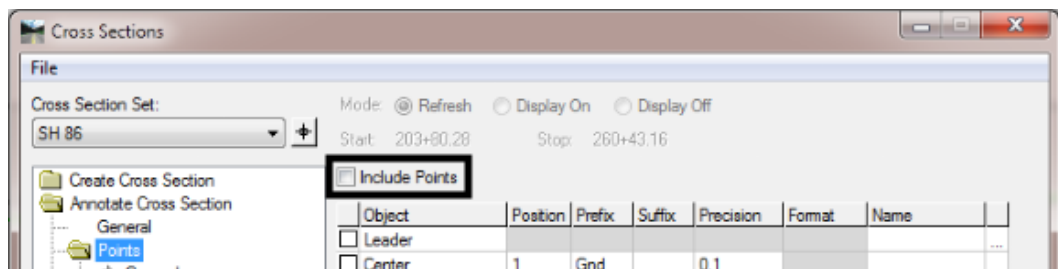


To review existing sideslope data, annotate the segments of the existing surface.

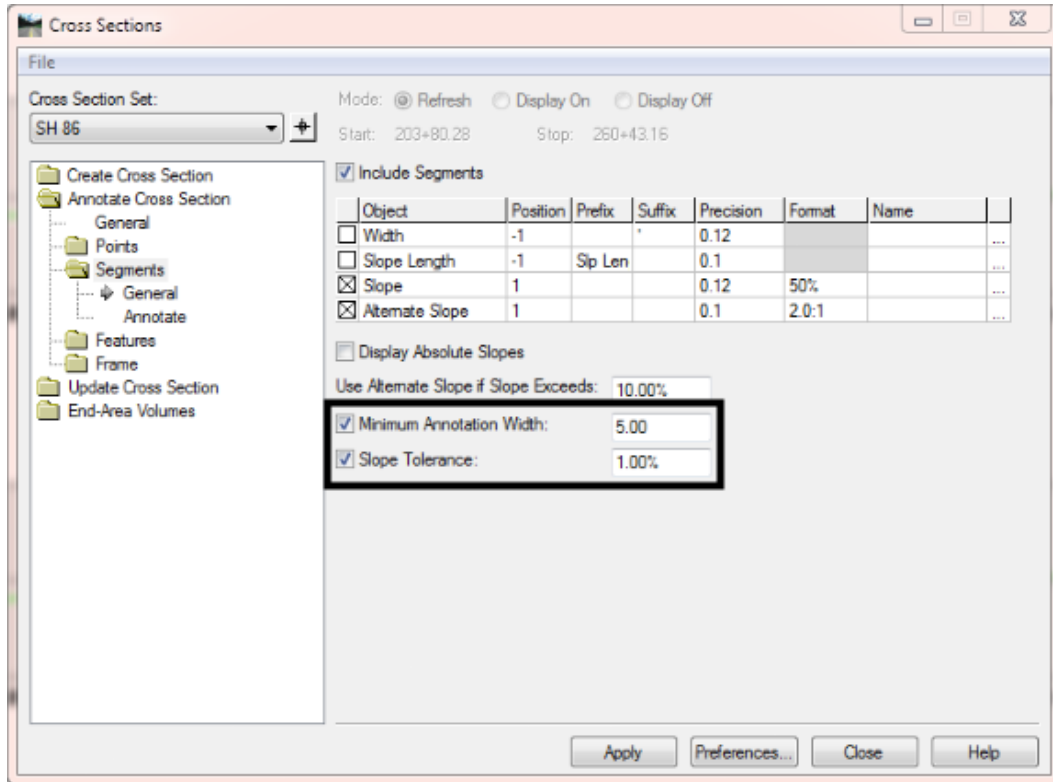
10. From the **Cross Sections** dialog box, select the **Annotate Cross Section** leaf.



11. Toggle off **Include Points** and **Include Features**.

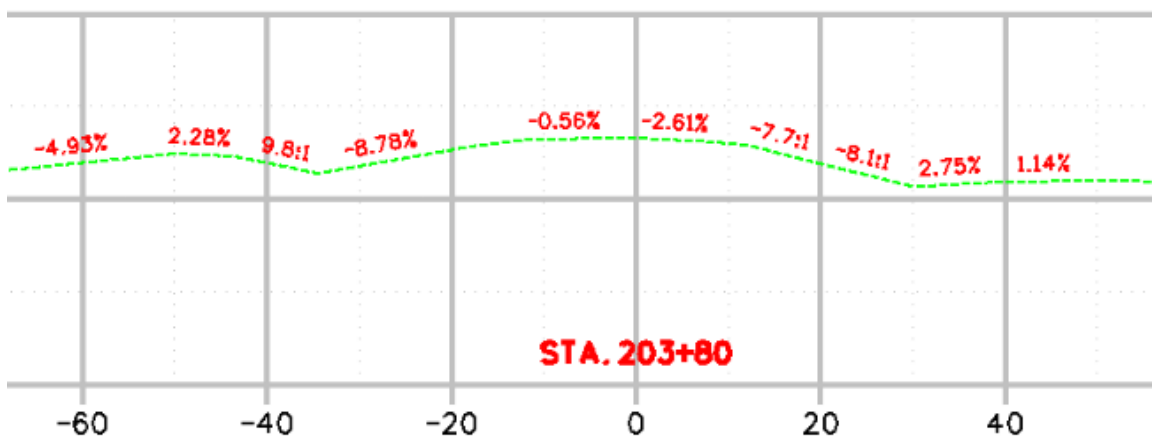


12. Toggle on **Include Segments**.
13. Toggle on **Minimum Annotation Width** and set the value to **5**.
14. Toggle on **Slope Tolerance** and set the value to **1.00%**.



These options allow for an adequate amount of annotation and keep the plans readable. If more annotation is required, adjust the values as needed.

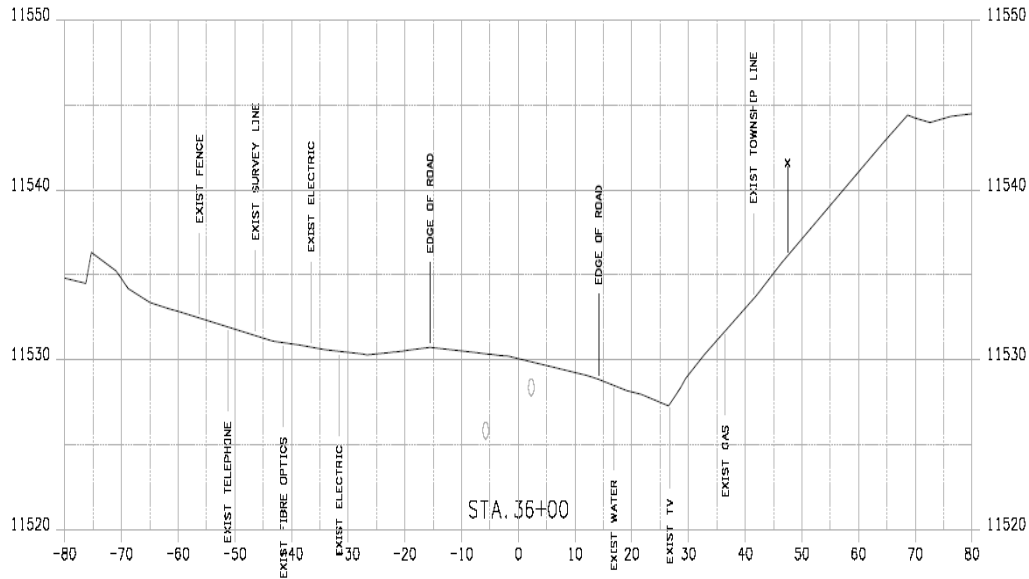
15. Left click the **Apply** button to display the annotation. Below is an example of cross sections with Segments annotated.



16. Close the **Cross Sections** dialog box and review the annotated sections.

Displaying Features in Cross Sections

Displaying existing surface features, like drainage structures, in the cross sections will help to evaluate design needs in areas that impact existing structures.

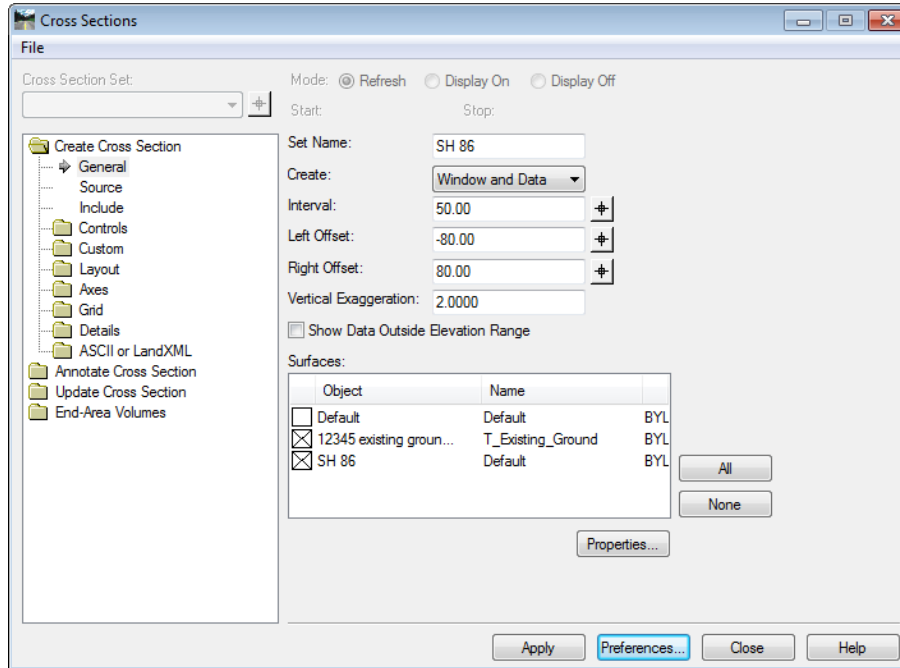


Note: Example Cross Section

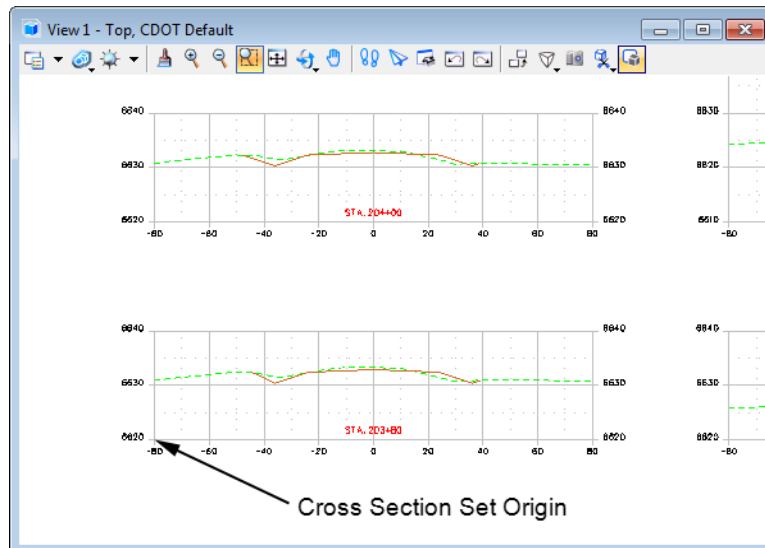
The procedure for displaying features in cross sections follows.

17. Verify that the **Global Scale Factor** is set to the desired scale prior to creating the cross sections.

18. From the InRoads, menu select **Evaluation > Cross Section > Cross Sections**. The **Create Cross Section** dialog box will appear. **Left click Preferences** to load the appropriate saved preferences. In this example the CDOT preferences will be used.

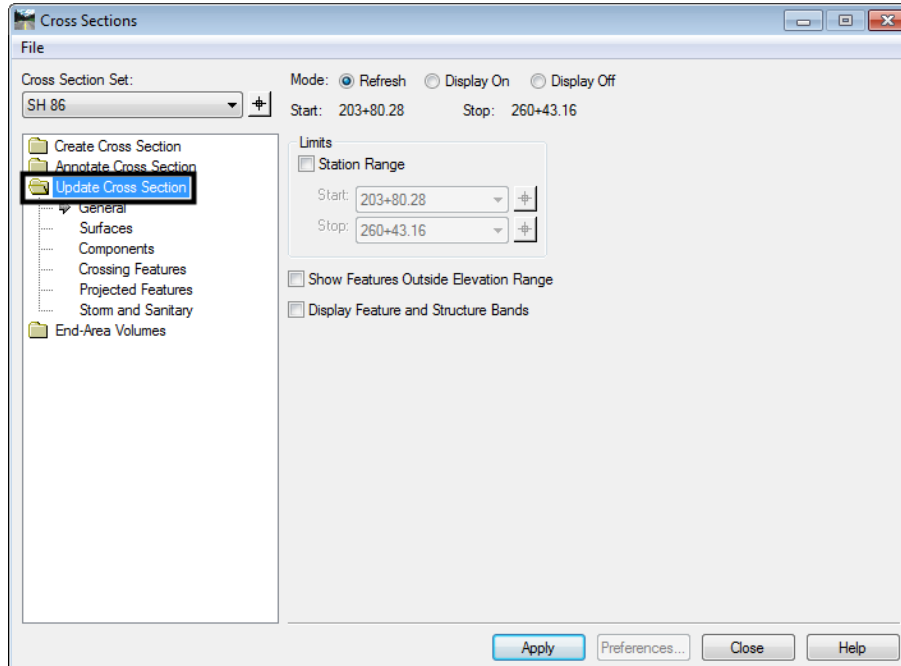


19. On the Include leaf in the Cross Sections dialog box, verify that Crossing Features and Projected Features are checked off.
20. Left click **Apply**. The dialog box will minimize allowing the selection of the origin for the cross section set with a Left click in a MicroStation View.



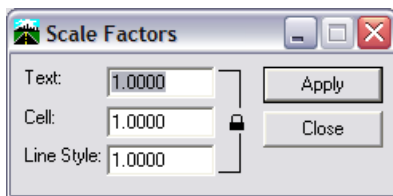
Display True Scale Cells

1. Left click the **Update Cross Section** folder in the dialog box explorer.



The first set of features to display will be the features that are defined to be true scale. These features have a defined size, such as pipes. In order to display these types of features properly, set the scale factor and feature filter prior to displaying.

2. Change the InRoads **Scale Factor** to 1.



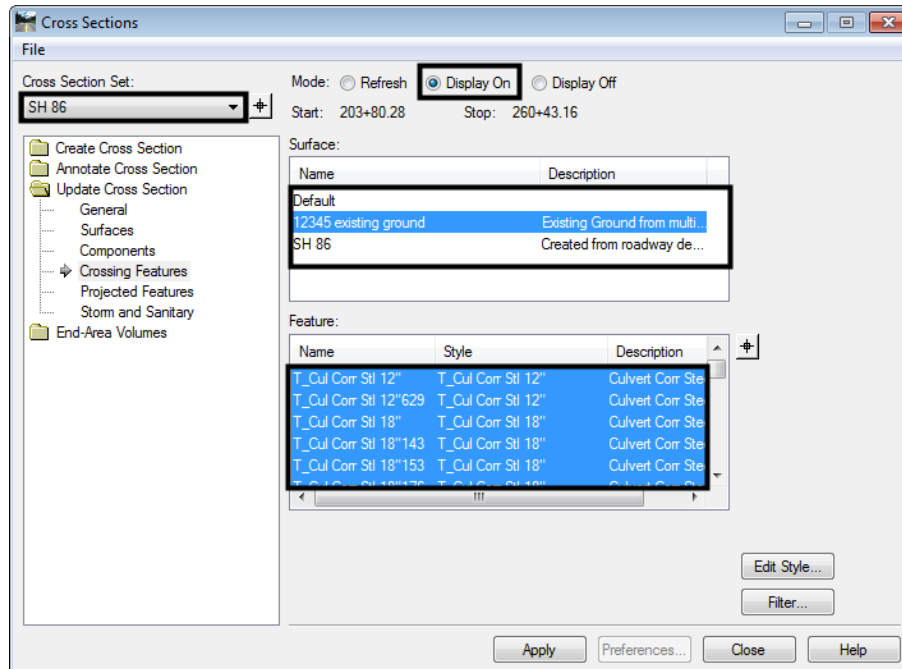
Note: Scale Factor should be 1:1 for true scale cells so that cells come in at actual scale.

3. From the **Locks** toolbar Select the **CELL_True-Scale** filter from the drop-down list and toggle on the **Feature Filter** lock button.



4. Verify the correct **Cross Section Set** selected.
5. Left click the **Crossing Features** Leaf.
6. Toggle on the **Display On** radio button.

- From the **Surface** list box, select the surface name or names to display. The **Feature** list box will then populate with the list of features found in the highlighted surface(s). Use the **Ctrl** or **Shift** keys to select multiple names. Also, by right clicking in the **Feature** list displays a menu that can be used to select all of the features.

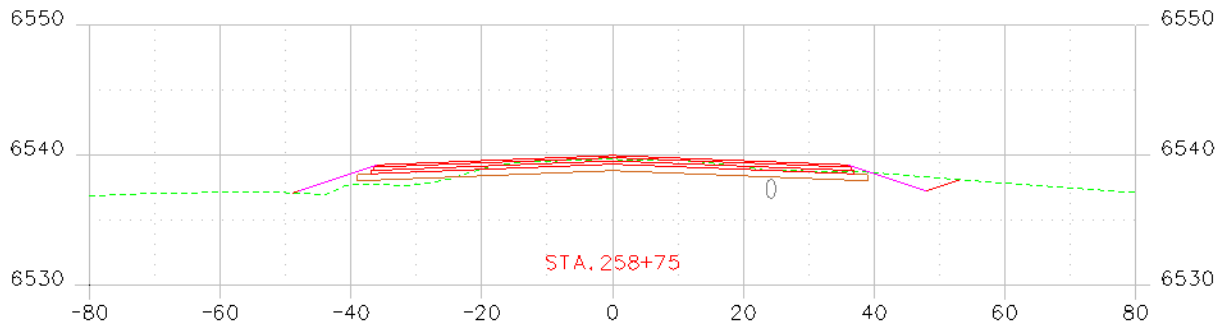


Note: The feature names in bold are Feature Styles that can be displayed in cross sections. Any names that are dithered are not configured to be displayed in a cross section view.

Note: If no features are shown in the feature list box, there are no features that meet the criteria for the filter selected in step 5. It may be necessary to associate the correct feature styles to the desired features if this is the case. Feature styles can be re-associated by using the **Surface > Feature > Feature Properties** command. See CDOT Update InRoads Features.pdf for more information on the process involved.

- Right click in the **Feature** list and then left click **Select All** from the menu. The Features that can be displayed in cross section view will be highlighted.

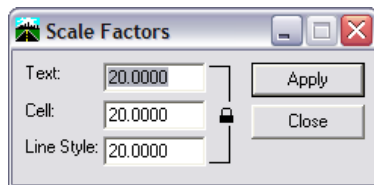
- Left click **Apply**. The dialog will minimize as the features are generated in the cross sections. When the process is finished, the dialog will reappear.



Displaying Plot Scale Cells

The second set of features to display is those that have *location only* defined with annotation. In order to display these types of features, the scale factor and the desired feature filter must be set prior to displaying.

- Change the InRoads Scale Factor to **20**.



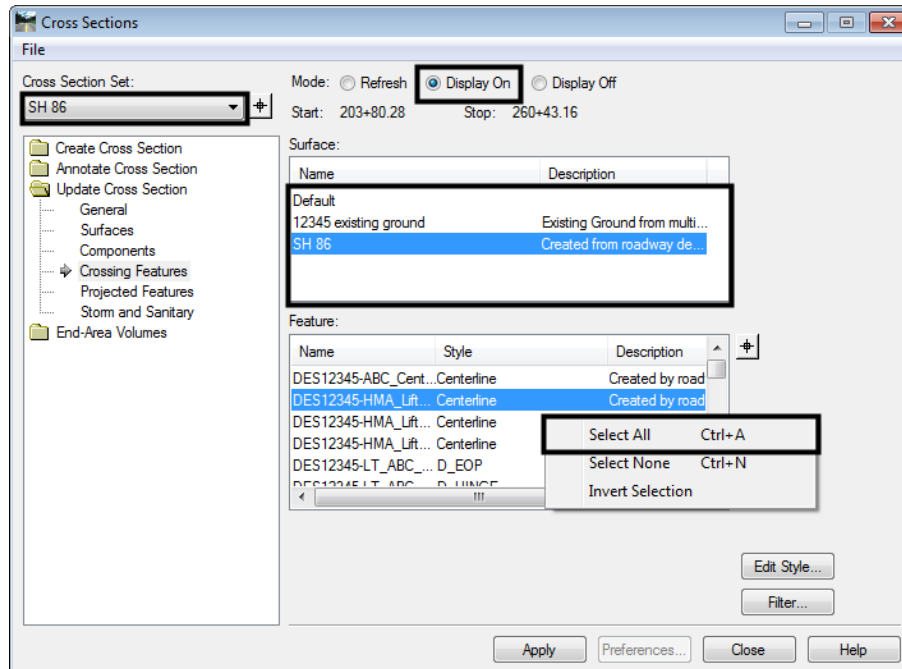
Note: This is the desired plot scale for the set of Cross Sections we are working with. The scale should be changed accordingly to match the scale of the original cross sections.

- From the **Locks** toolbar select the **CELL_Plot-Scale** filter from the pull down list. Verify that the feature filter is toggled on.



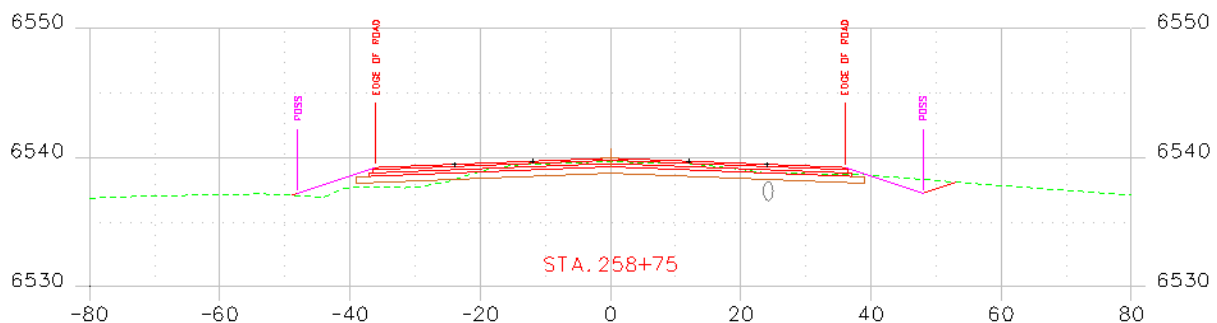
- Verify that the correct **Cross Section Set** is selected.
- Left click the **Crossing Features** Leaf.

- From the **Surface** list box, select the surface name or names to display. Once a surface or surfaces are selected, the **Feature** list box will populate with the list of features. Use the **Ctrl** and **Shift** keys to select multiple feature names. Also, by right clicking in the **Feature** list displays a menu that can be used to select all of the features.



Note: The names in bold are Feature Styles that can be displayed in cross sections. Any names that are dithered are not configured to be displayed in a cross section view.

- Left click **Apply**. The **Update Cross Section** dialog box will minimize as the features are generated in the cross sections. When the process is finished, the dialog will reappear.



2. Setting Design Parameters and Reviewing Design Data

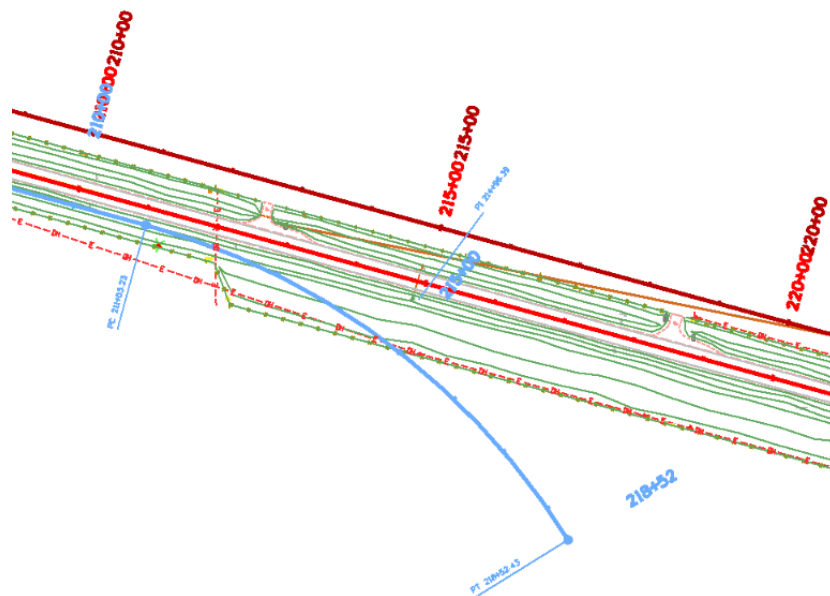
This includes various settings that control where design data is generated and how data is displayed in MicroStation. Each task in creating design data should be reviewed as it is completed so that the next task will start with the most accurate data possible.

a. Geometry Review

- i. **Reviewing Horizontal Geometry** – In creating a design model multiple horizontal alignments can be used. These alignments should be reviewed individually and as they relate to each other to ensure that they meet the designer's intent.

The first review of horizontal geometry should be visual. Start with the project mainline alignment. Display the alignment and its stationing into the JPC#DES_Model.dgn file then reference in the JPC#SURV_Topo_Scale##.dgn file. This allows the designer to see the topo in relation to the design corridor. Verify that the alignment is completely within the surveyed area. If the alignment is partially outside the surveyed area additional survey will be required. If it is wholly outside the survey area then it must be determined why the two datasets do not match up.

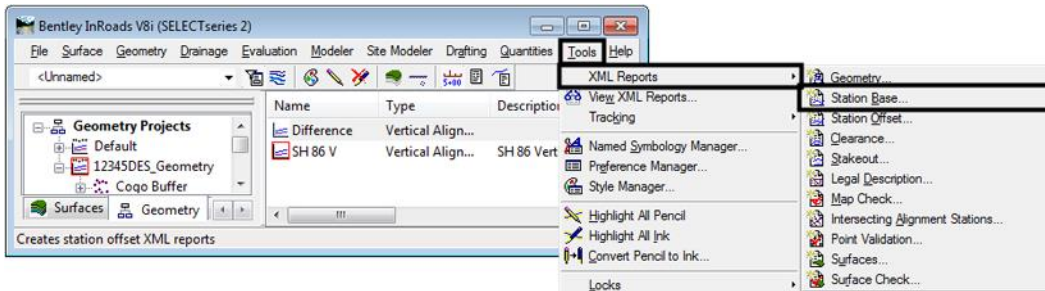
Review the other alignments associated with the project in the same manner. The illustration below shows the main alignment in light red, a secondary alignment in dark red, and a diverging alignment in blue.



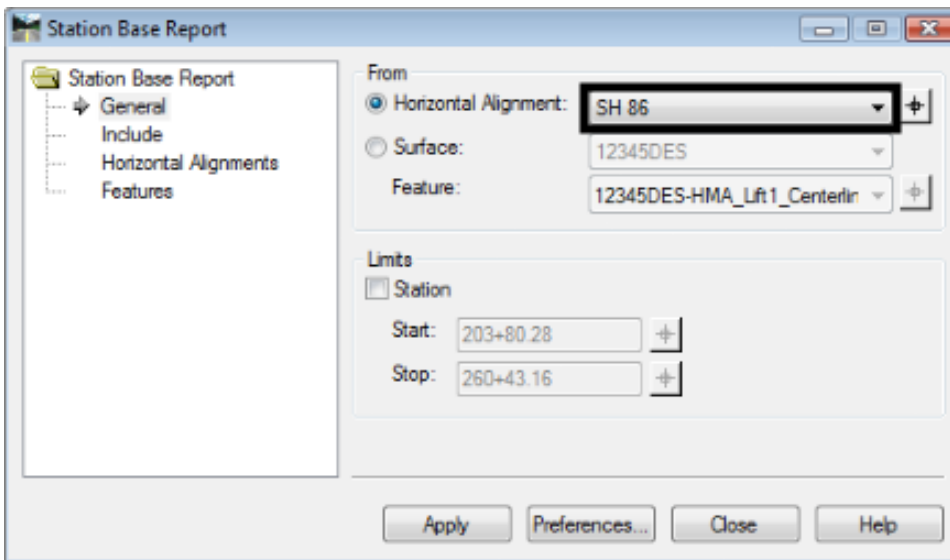
After these have been reviewed against the topo they should be review against the main alignment and each other. In addition to a visual review, InRoads has reports that could be

helpful. For example, the Station Base report shows offset distances from the main alignment to other alignments at a specified interval. To create a Station Base report:

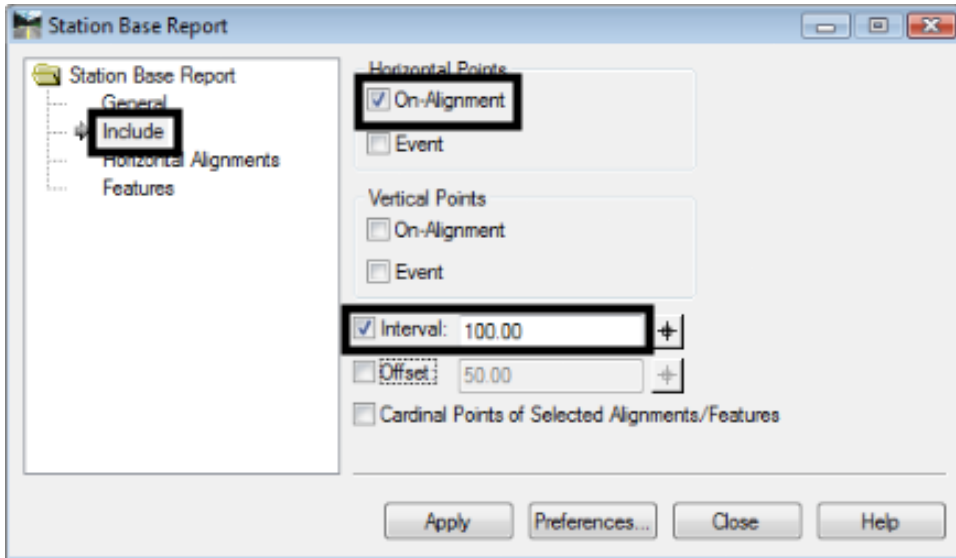
1. Select **Tools > XML Reports > Station Base** from the InRoads menu bar.



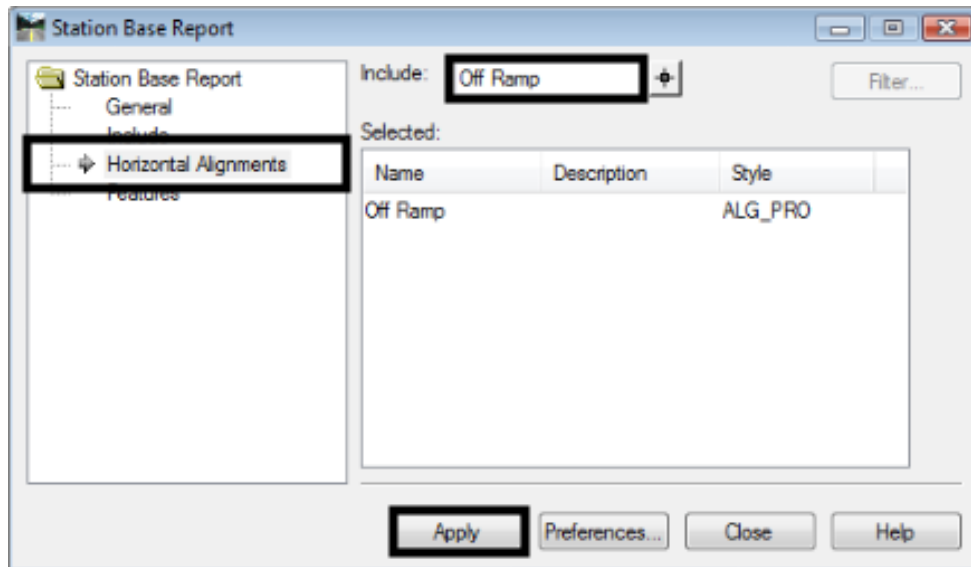
2. On the **General** leaf of the **Station Base Report** dialog box, select the desired **Horizontal Alignment**. In this example SH 86 is used.



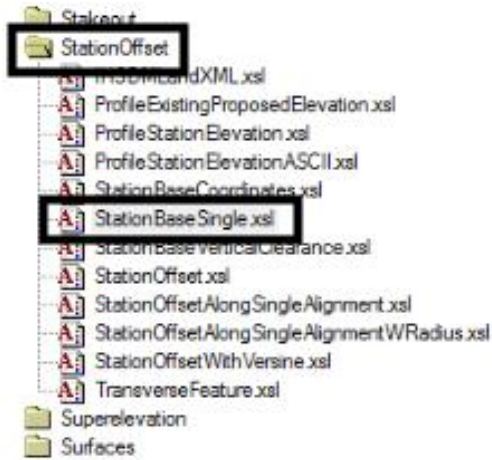
3. Select the Include leaf.
4. In the **Horizontal Points** area, toggle on **On-Alignment**.
5. Toggle on **Interval**.
6. Key in the desired **Interval** value.



7. Select the **Horizontal Alignments** leaf.
8. In the **Include** field, key in the desired alignment name (Off Ramp in this example) and press the **Tab** key.
9. Left click the **Apply** button. This displays the Bentley InRoads Report Browser.



- In the **Bentley InRoads Report Browser**, select the **StationBaseSingle.xml** from the **StationOffset** folder in the left pane.



- Review the report in the left pane.

Station Base Report

Report Created: 4/1/2009
Time: 1:13pm

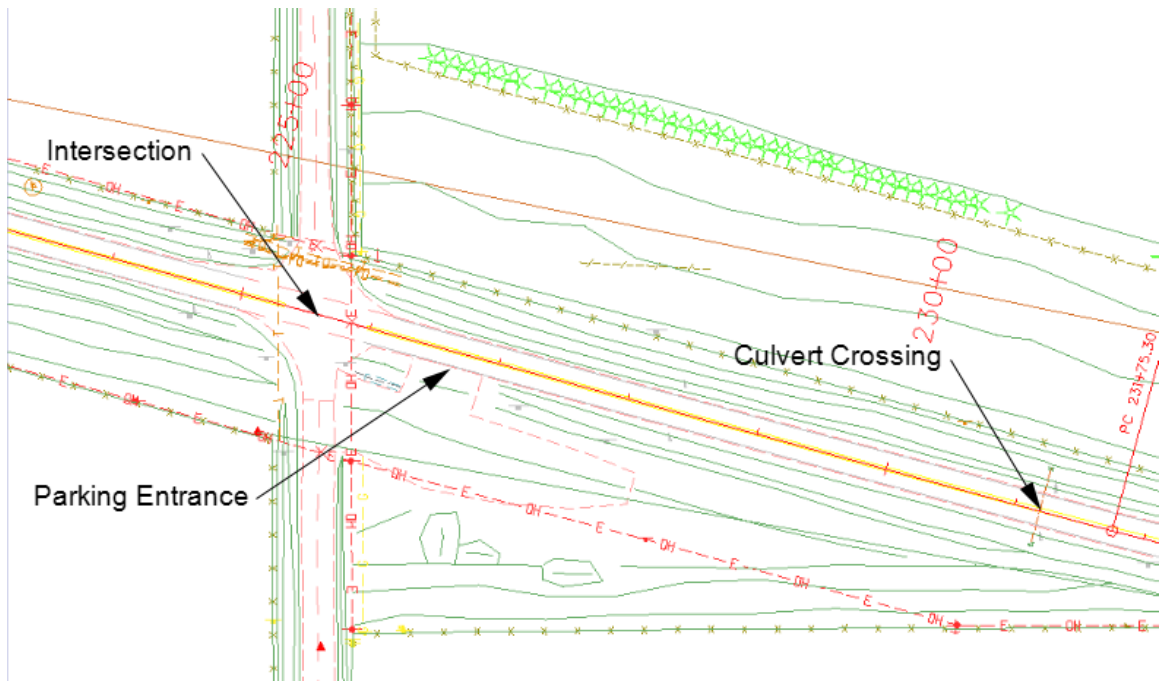
Project: 12345DES_Geometry
Description: SH 86 Design geometry
Baseline (Active) Alignment: SH 86
File Name: C:\Projects\12345\Design\InRoads\12345DES_Geometry.alg
Last Revised: cferree 4/1/2009 11:19:47 AM
Input Grid Factor: 1.00000000 Note: All units in this report are in feet unless specified otherwise.

----- Baseline Alignment -----			----- Offset Alignment -----		
Station	Distance to Offset Point	Radial Direction	Station	Distance to Offset Point	Radial Direction
Offset (Specified) Alignment: Off Ramp					
205+00.00	0.00	S 15°14'41" W	1+00.00	24.00	S 15°14'41" W
206+00.00	0.00	S 15°14'41" W	2+00.00	24.00	S 15°14'41" W
207+00.00	0.00	S 15°14'41" W	3+00.00	24.00	S 15°14'41" W
208+00.00	0.00	S 15°14'41" W	4+00.00	24.00	S 15°14'41" W
209+00.00	0.00	S 15°14'41" W	5+00.00	24.00	S 15°14'41" W
210+00.00	0.00	S 15°14'41" W	6+00.00	24.00	S 15°14'41" W
211+00.00	0.00	S 15°14'41" W	7+00.00	24.00	S 15°14'41" W
212+00.00	0.00	S 15°14'41" W	8+00.15	28.69	S 20°47'52" W

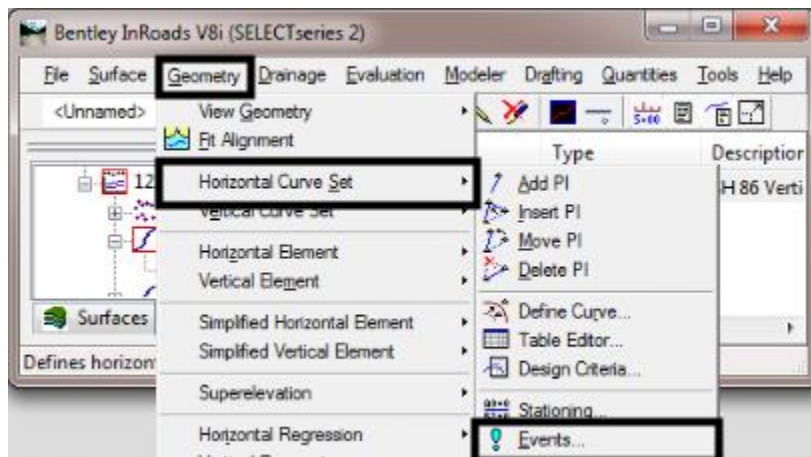
Note: There are other Station Base style sheets that may be helpful, like **StationBaseCoordinates.xml** and **StationBaseVerticalClearance.xml**.

ii. **Enter Event Points for areas of special concern** - Event points are those locations along the design path (horizontal alignment) that require additional attention during the design process. These include drainage structure crossings, driveways and entrances, intersections, etc. Once the horizontal alignment has been laid out, the process of identifying and storing Event Point can begin.

2. Zoom in to the beginning of the alignment close enough so that items of interest can be easily identified. In the example below, three items are identified; the intersection, a parking area entrance, and a culvert crossing.

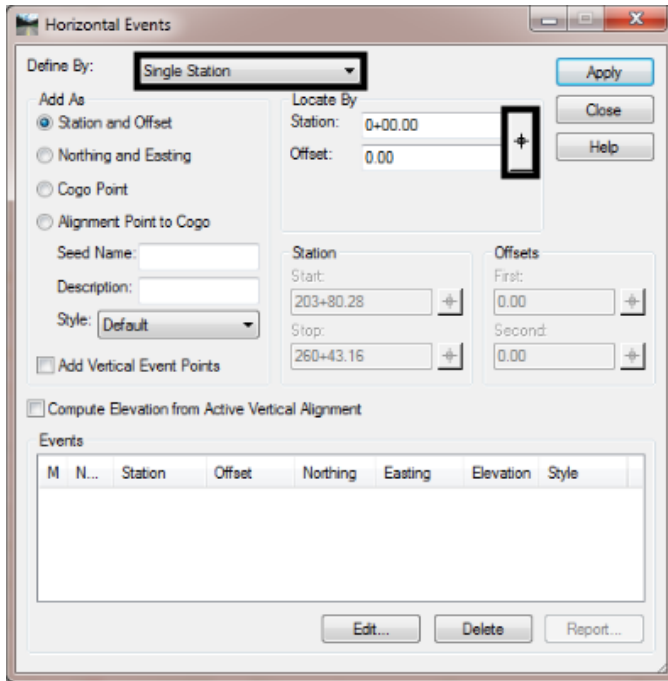


3. To create an Event Point for the culvert, from the InRoads main menu select **Geometry > Horizontal Curve Set > Events**. This displays the **Horizontal Events** dialog box.

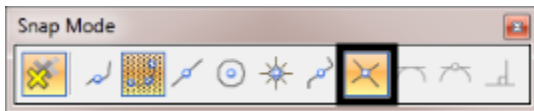


4. In the **Horizontal Events** dialog box, set *Define By* to **Single Station**.

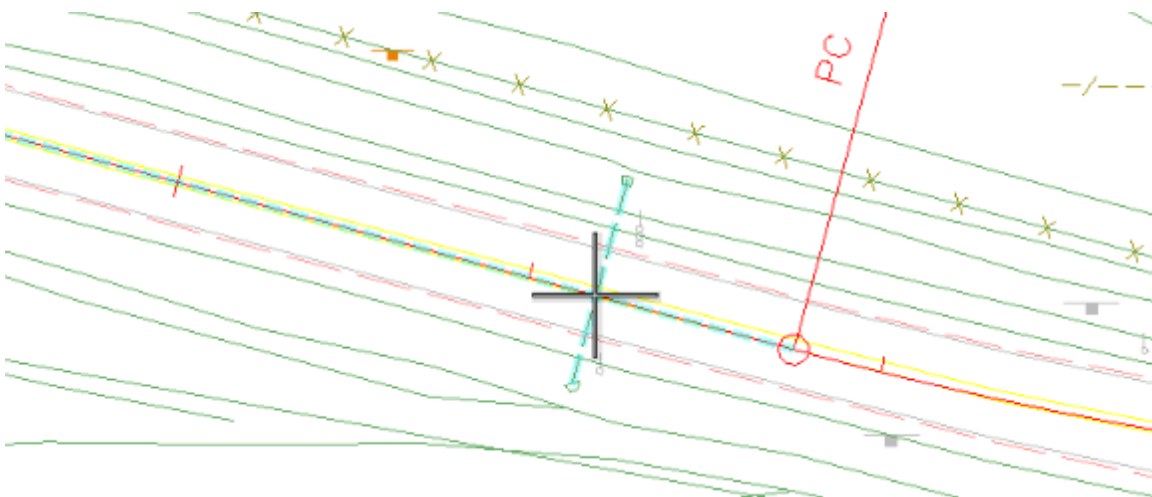
5. Click the target button  to activate the command.



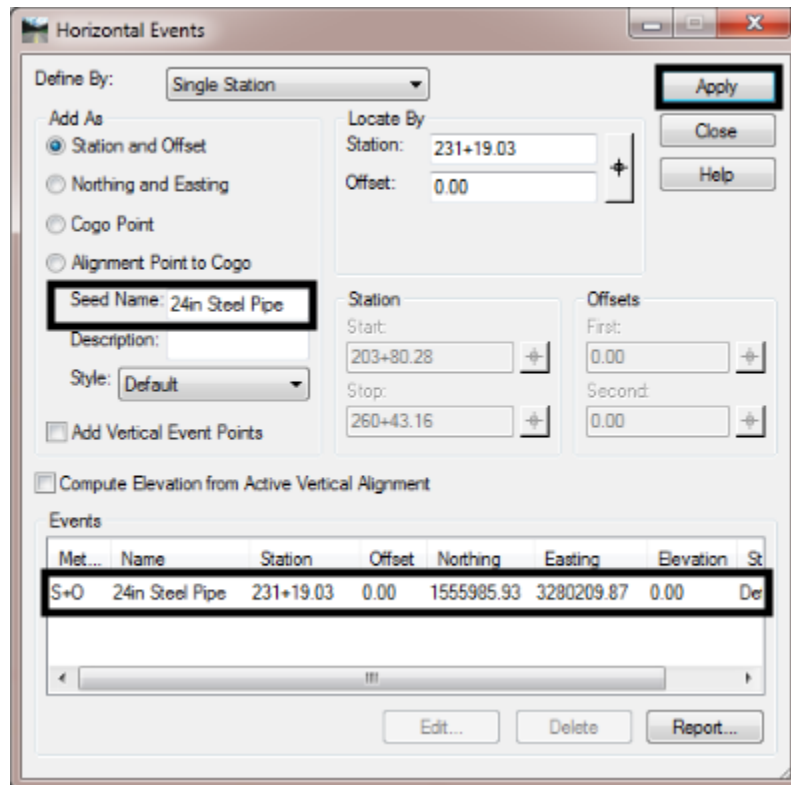
6. Select the Intersection snap mode from the **Snap Mode** tool bar (*Note: This toolbar may be docked*).



7. Tentative snap to the intersection of the culvert crossing and the horizontal alignment. Left click to accept the location.



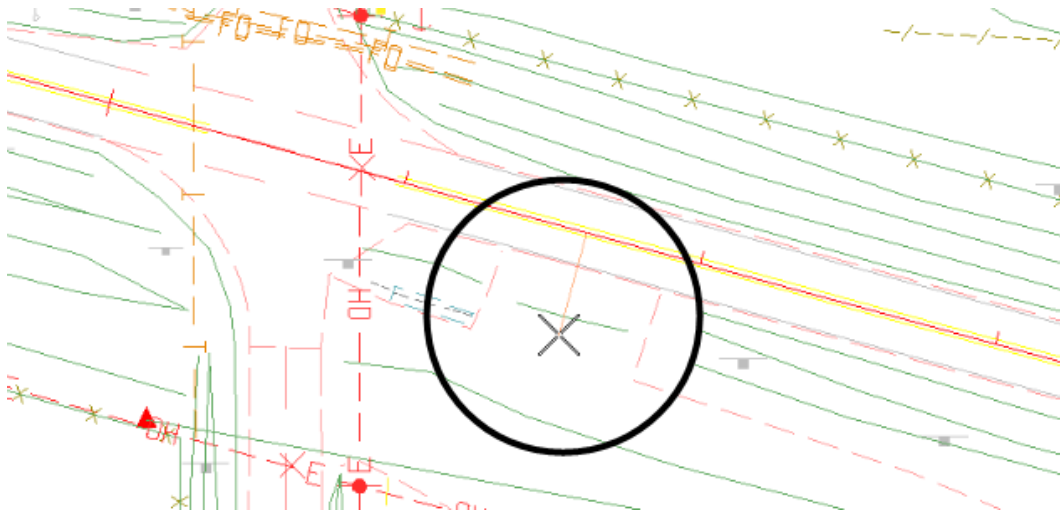
8. The station value is entered into the dialog box. A **Name** for the event point can be entered if desired. This will help identifying what each event point represents. In the **Seed Name** field, key in the desired name.
9. Click the **Apply** button to complete the command. The event point is added to the list at the bottom of the dialog box.



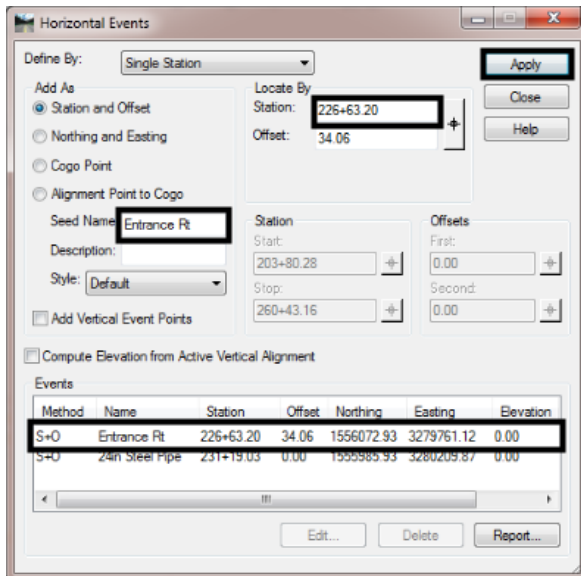
The same method can be used for any item that crosses the alignment, like an intersection. To add an Event Point for an item that does not cross the alignment:

10. Repeat steps 1 through 5 above as needed.

- Position the cursor in the center of the item and left click. If the item is a point feature or has a line equal to the width of the item, tentative snap to the center of the element then left click. The illustration below shows the cursor positioned in the center of the parking entrance.

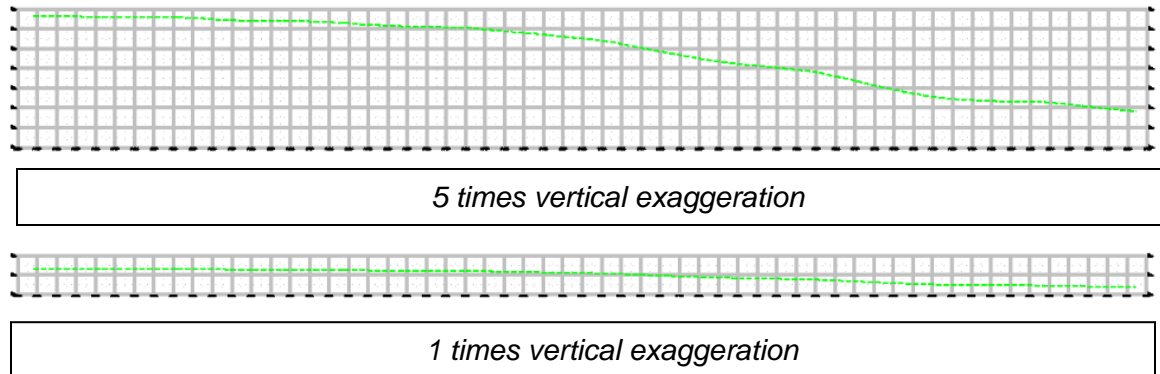


- Adjustments to the **Station** value can be made within the **Horizontal Events** dialog box prior to clicking the **Apply** button. In the Seed Name field, key in the desired name.
- Click the **Apply** button to complete the command. The illustration below shows the dialog box entries for the parking entrance event point.



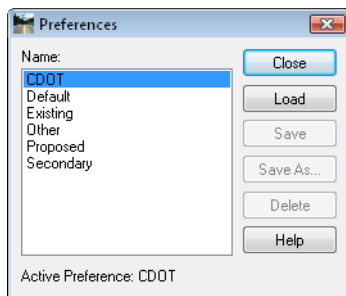
iii. **Reviewing Vertical Geometry** – Mainline vertical geometry is a major determining factor in the amount of earthwork required for a project.

1. **Profile Exaggeration** – Choosing the appropriate exaggeration can make laying out and reviewing a vertical alignment much easier. As a general rule, one should use a larger exaggeration factor on projects with flatter terrain. The illustration below shows two profiles of the same area. The bottom profile was created with an exaggeration of 1 and the top profile with an exaggeration of 5. The higher exaggeration of the top profile makes grade changes much easier to see.



When drawing or measuring in a profile using MicroStation commands, the vertical exaggeration is not accounted for. The exception is when drawing using the **Station / Elevation** or **Distance / Grade** precision key ins. Using the InRoads **Vertical Alignment Tracking** does account for the vertical exaggeration.

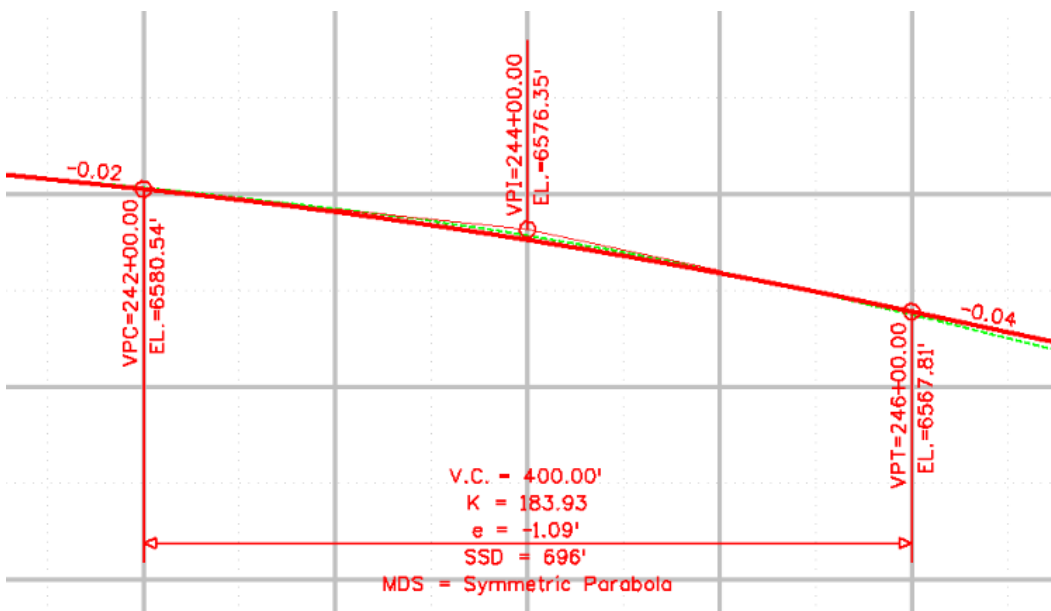
2. **Annotating Profiles** – The first step in annotating a profile is to display the vertical alignment annotation. To view the vertical alignment annotation:
 1. From the InRoads menu bar, select **Geometry >View Geometry > Vertical Annotation**. This displays the **Vertical Annotation** dialog box.
 2. Verify the appropriate **Horizontal**, and **Vertical Alignments** are identified in addition to the **Profile Set**.
 3. Select **Preferences**, **Load** the desired preference then **Close** the **Preferences** box.



4. Left click the **Apply** button to display the vertical alignment and its annotation.

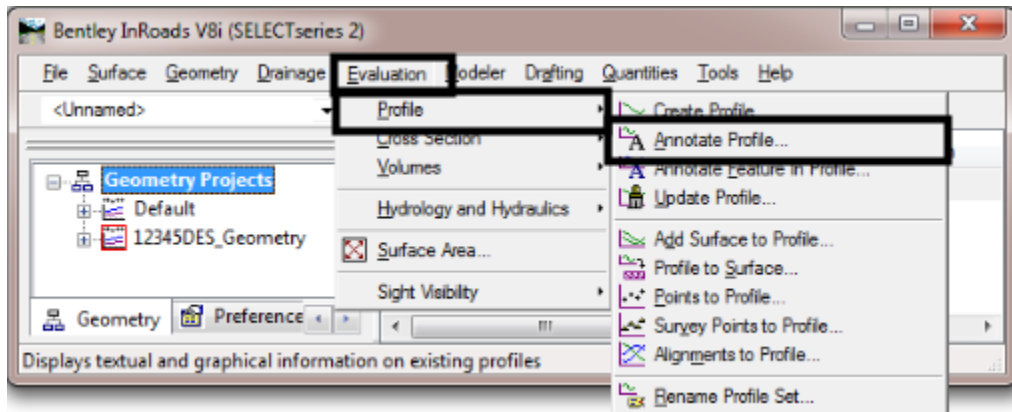


The illustration below shows an example of vertical alignment annotation.

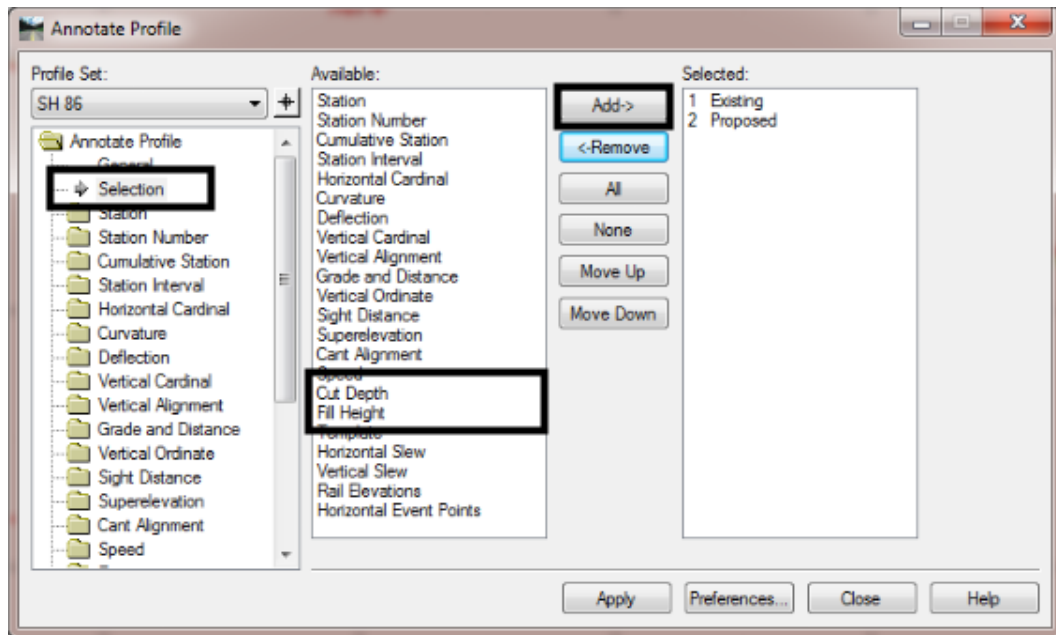


Additional annotation is displayed using the Annotate Profile command:

- From the InRoads menu bar, select **Evaluation > Profile > Annotate Profile**. This displays the **Annotate Profile** dialog box.



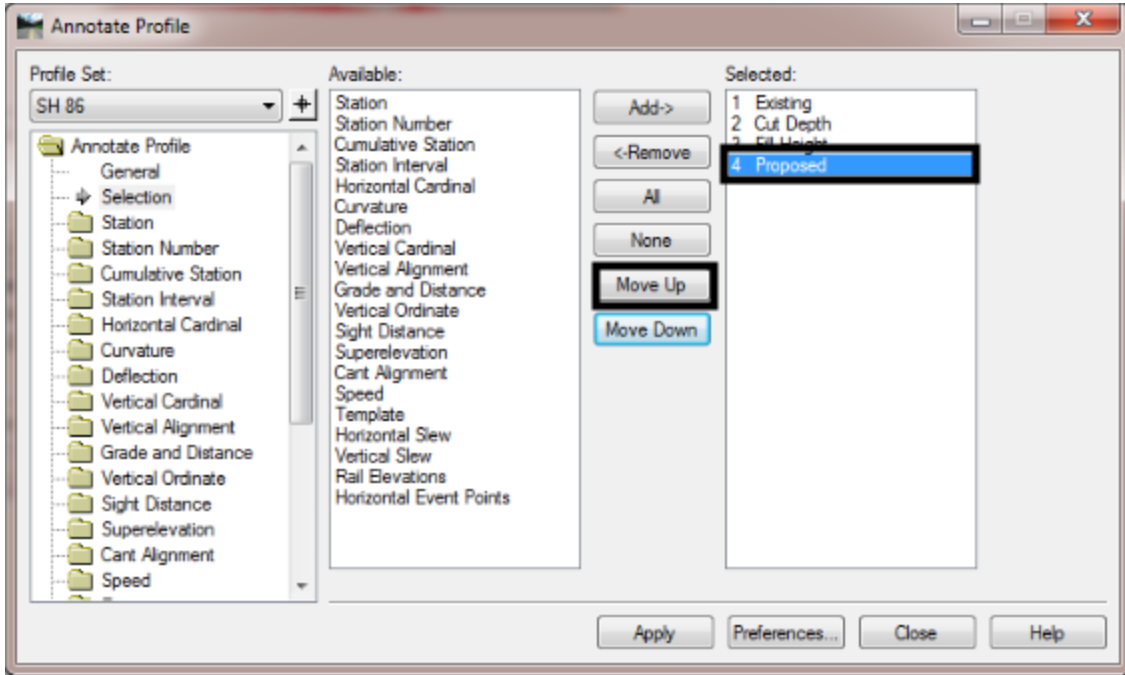
- In the **Annotate Profile** dialog box, select the Selection leaf.
- In the **Available** column, select the desired items to annotate. **Cut Depth** and **Fill Height** are selected in this example.
- Left click the **Add** button. This moves the highlighted items from the **Available** column to the **Selected** column.



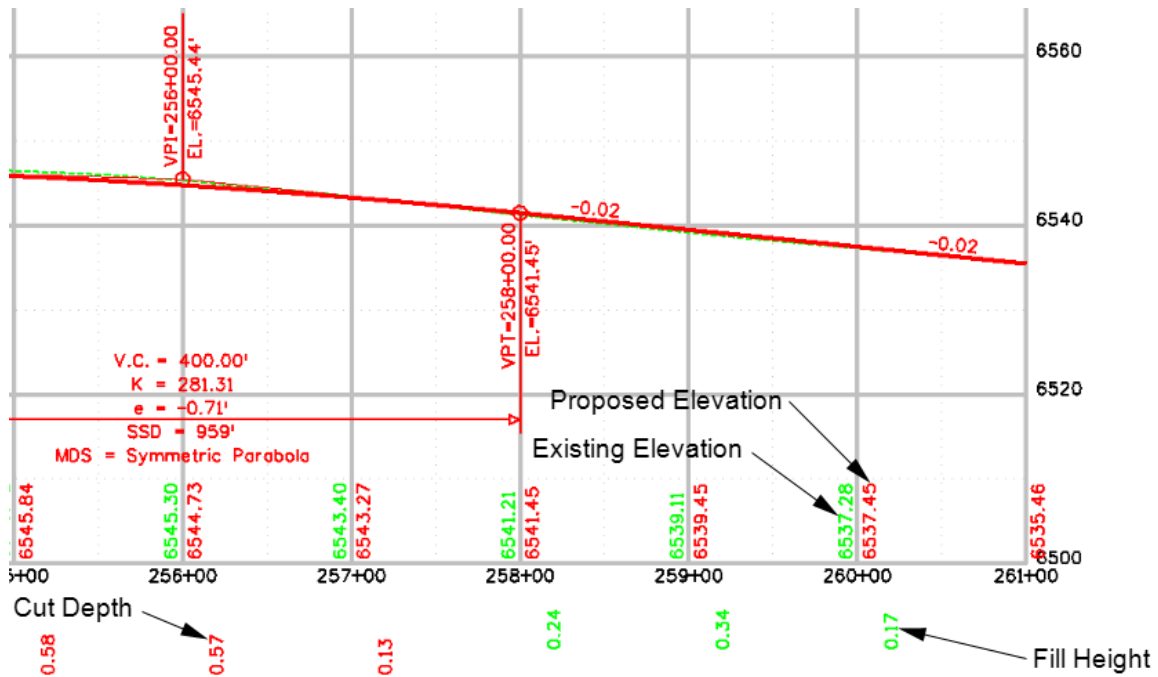
In this example, the two added items moved into slots 2 and 3, while **Proposed** was moved to slot 4. In order for all items to display properly, **Existing** must be 1 and **Proposed** must be 2. To move **Proposed** back to slot 2:

- Highlight Proposed in the **Selected** column.

10. Left click the **Move Up** button until **Proposed** is back at the 2 slot.



11. Left click the **Apply** button to initiate the command. The selected annotation is displayed in or near the profile. The illustration below shows examples of existing and proposed elevations, cut depth, and fill height.



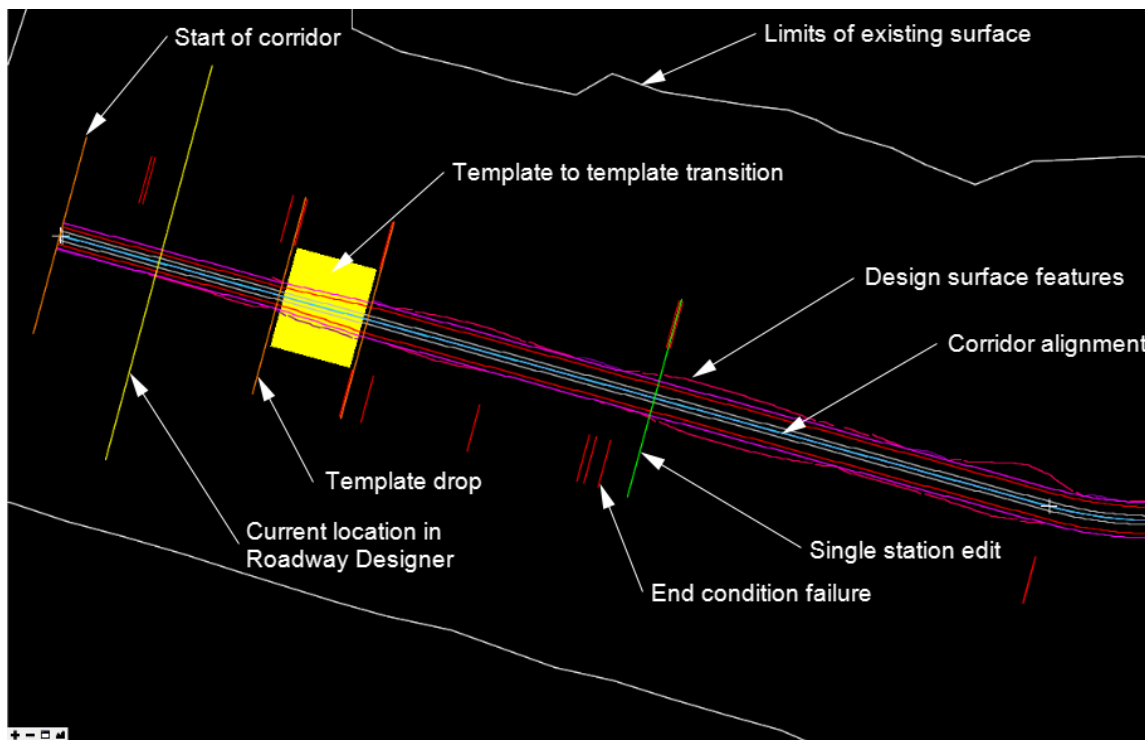
b. Roadway Designer Set up and Review

Using the proper settings in Roadway Designer will allow the user to create an accurate model by delivering appropriate feedback and creating design data at the required locations.

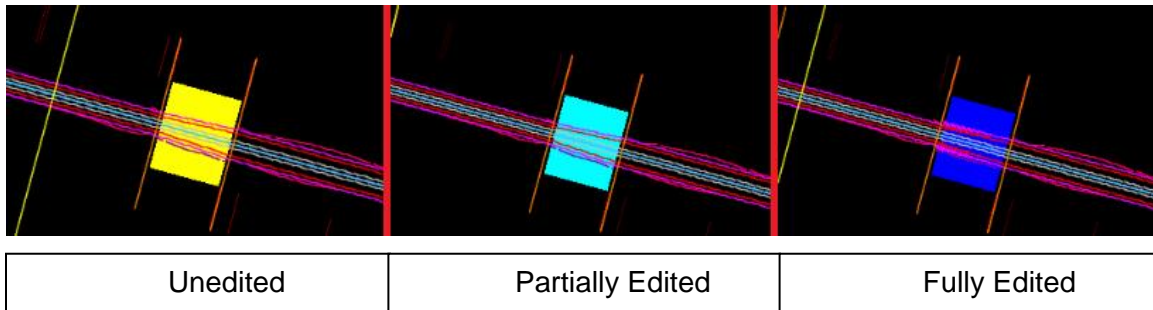
- i. **Setting up and reading Roadway Designer displays** – Roadway Designer can be set to automatically process additional template drops at critical stations. These include Event Points defined in the corridor alignment, P.C.s and P.T.s, Superelevation transition stations, Point Control stations, etc.

There are also various display options available. Some items, like the plan display are controlled by the software. Other items that are displayed in the cross section view can be toggled on as needed.

To understand the plan view display, examine the illustration below:



The template to template transition symbology changes based on the amount of editing done on the transition. The illustration below shows the three states of a template to template transition. The left image shows the initial state when no editing has been done. The center image shows that some but not all editing has been done. The right image shows the transition with all points connected.



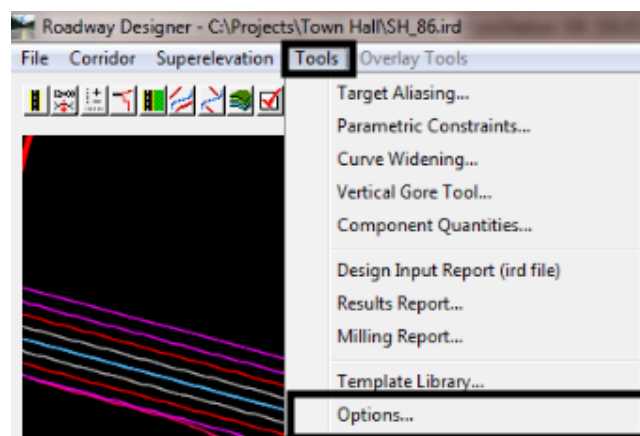
The basic cross section display shows the existing ground and the template with its components. The following additional information can be added to the various Roadway Designer displays:

- **Reference Graphics** – User specified alignments or surface features that are displayed in the plan and cross section views to show the relationship of the selected item to the design model. These are shown as solid magenta lines in the plan view and dashed magenta lines or bold “+” signs in the cross section view.
- **Transition Graphics** – Plan view graphics that show where template to template transitions occur and their editing status. These are displayed as described above.
- **Triangulated Surface** – Plan view graphics that show the top of the triangulated design surface. It is displayed as a bold dashed line in the color of the corridor's surface symbology.
- **Cut and Fill Graphics** – These are colored shapes that show where existing surface material is removed (cut=green) and where additional material is brought in (fill=red). Additionally, a bold blue line shows where on the template fill is calculated to.
- **Cut and Fill Values** – This cross section display shows the Cut Area and the Fill Area of the current template drop. Because it does not look back at the previous template drop, the volumes remain at 0.00.
- **Net Volume** – This cross section display shows the Mass Ordinate for all of the processed template drops up to the current location.
- **Null Points** – This cross section display shows the location of Null Points within the template. They are displayed as bold “+” signs in the color relating to the number of constraints applied to the point.
- **Curve Set ID** – These are displayed in the Plan and Profile views. They are displayed as numbers relating to their location within the horizontal (plan view) or vertical (profile view) alignments of the active corridor.

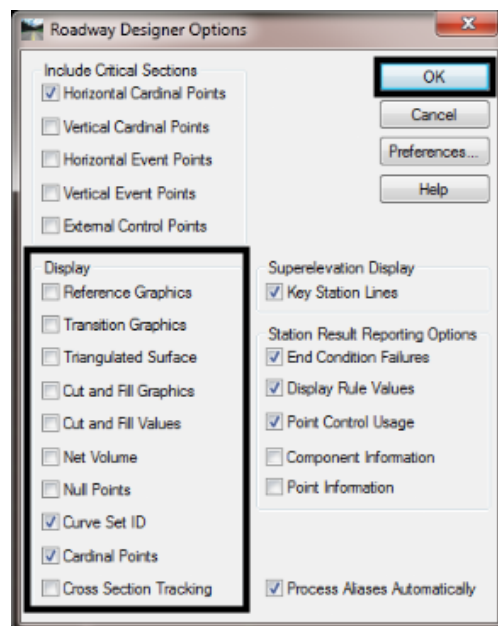
- **Cardinal Points** – These are displayed in the Plan and Profile views. They represent PCs, Pts, PVCs, and PVTs of the active corridor's horizontal and vertical alignments. They are displayed as normal white "+" signs.
- **Cross Section Tracking** – This cross section display is attached to the cursor while it is in the cross section view. It shows the offset distance from the corridor alignment and the elevation of the cursor's location. If the cursor is within the limits of the design model, it also shows the slope value of the design surface directly above or below the cursor.

To select the desired options:

7. From the Roadway Designer menu bar, select **Tools > Options**. This displays the **Options** dialog box.



8. In the **Options** dialog box **Display** area, toggle on the desired options.
9. Left click the **OK** button.



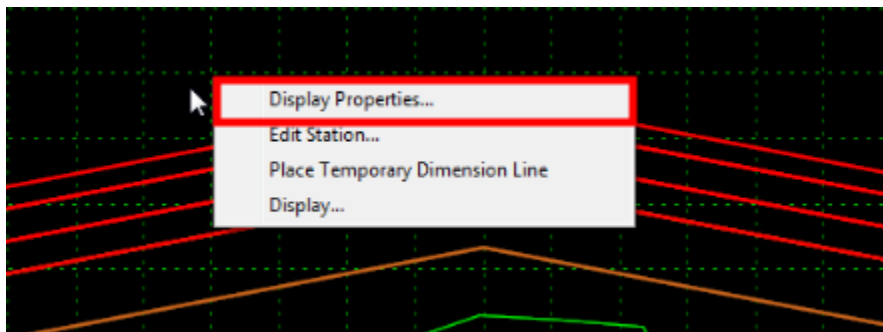
Turn on only the items to be reviewed at that time. Having too many things on at once can obscure the cross section and make things difficult to read.

Other display options have to do the exaggeration of the cross section view. These are:

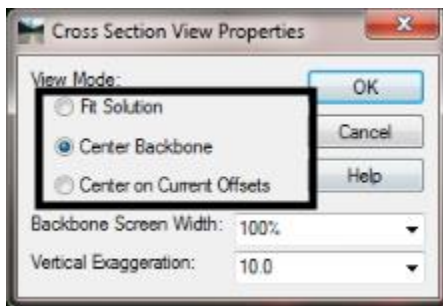
- **Fit Solution** – This option adjusts the horizontal and vertical exaggeration so that the entire design model fits into the cross section view.
- **Center Backbone** – The user specifies the amount of the template backbone that will be displayed in the cross section view and sets a value for the vertical exaggeration
- **Center on Current Offsets** – The software computes the backbone that will be displayed in the cross section view and vertical exaggeration based on the current zoom factors. Anytime the zoom is adjusted the new zoom value is used when the station is advanced.

To access the cross section display settings:

1. Right click in the cross section view port.
2. Select **Display Properties**. This displays the **Cross Section View Properties** dialog box.



3. Toggle on the desired **View Mode**.

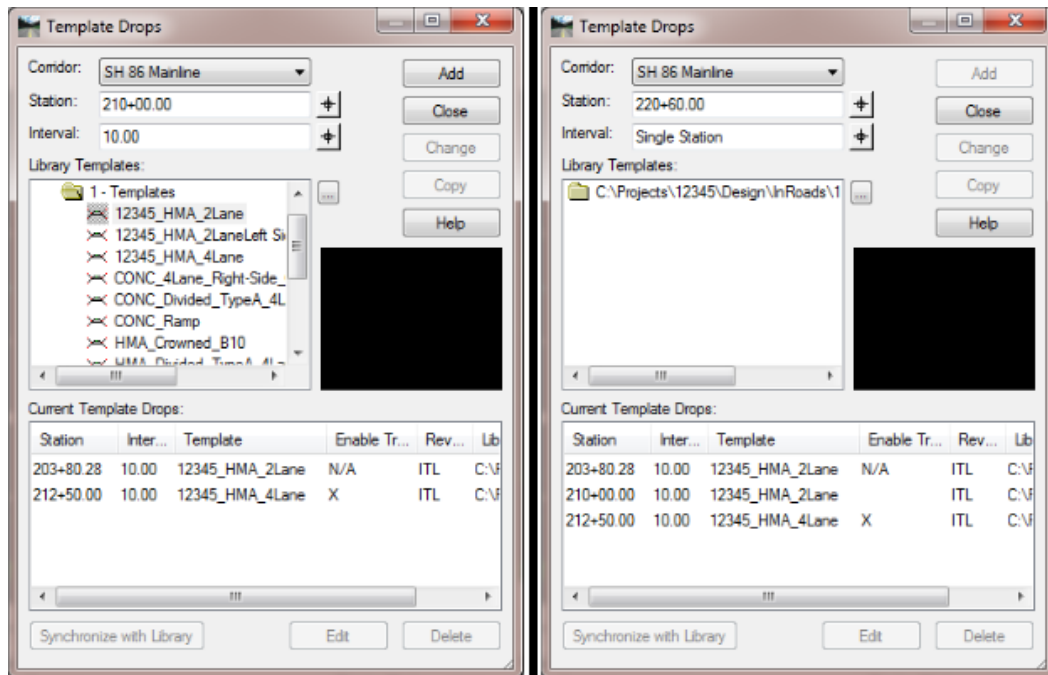


4. If either of the Center options are selected, the **Backbone Screen Width** and **Vertical Exaggeration** can be set.
5. Left click the **OK** button. This applies the settings and dismisses the dialog box.

Fit Solution is the View Mode most commonly used. It ensures that the entire template is always visible. Because of their static exaggeration settings, the Center options are best for verifying template cross slopes and checking for changes in backbone width in transition areas.

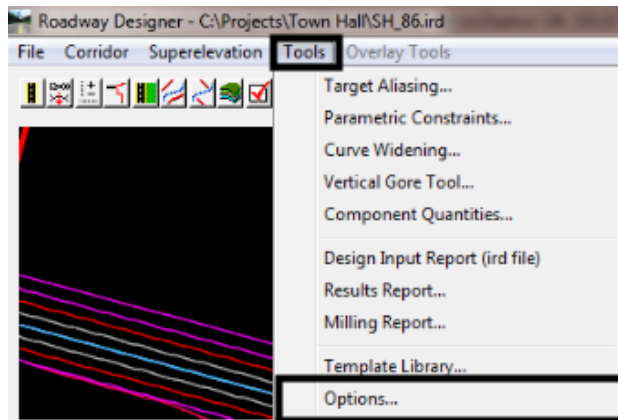
- ii. **Template Drop Interval** – The template drop interval determines how often design data is processed along the corridor. The recommended maximum template drop interval is 10'. In areas of complex modeling (intersections, for example) a 1' interval is specified. These intervals were selected to provide a balance between accuracy and intricacy of the model with the ability to provide a clean and useable model suitable for use with Automated machine Control.
- iii. **Changing Templates** – There are two options to choose from when changing templates along a corridor, to transition or not to transition. The transition option should be used when the two templates have the same basic structure and only the width is different. Do not transition between templates when the pavement structure is different (curb and gutter to open section or asphalt to concrete, etc.).

When using the transition option, the transition occurs over the distance from the last template drop of the first template to the first template drop of the next template. In the illustration below, the left image shows two template drops. Based on the stations of those template drops, the transition occurs over 869.72 feet. In the right image a second template drop has been added that uses the first template. This reduces the transition length to 250 feet.

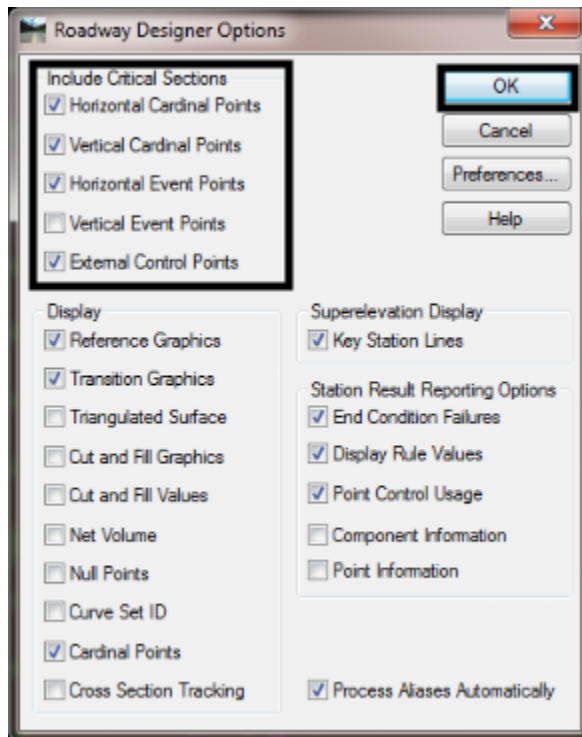


iv. **Using Event Points and other important stations** – Additional template drops should occur at event points (defined in the geometry project), geometry cardinal points, superelevation transitions, and external control locations.

1. From the Roadway Designer menu bar, select **Tools > Options**. This displays the **Options** dialog box.




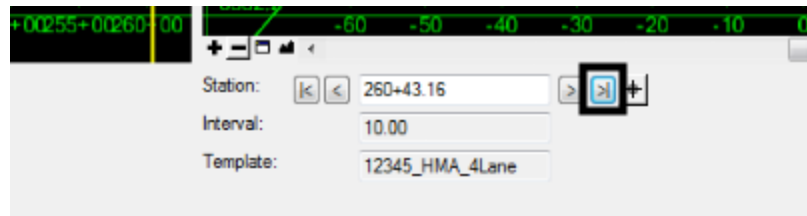
2. In the **Options** dialog box **Include Critical Sections** area, toggle on the desired options.
3. Left click the **OK** button. The illustration below show the typical settings for the **Include Critical Sections** area.



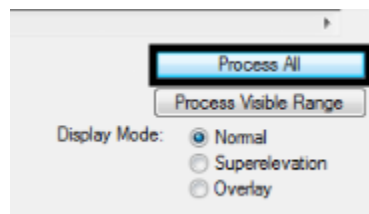
Point controls, parametric constraints, and Superelevation transition stations are **External Control Points**.

- v. **Review Component Quantities** - The Component Properties command gives a volume total of the surfacing components and the area of linear components. Components that use the same feature style are lumped together into a single quantity. To generate Component Properties:

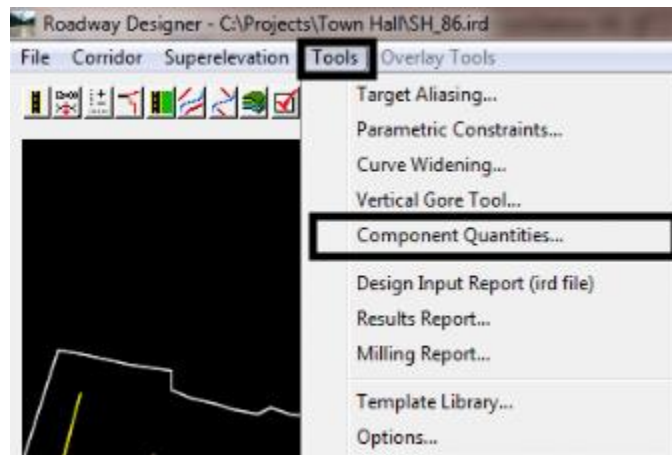
1. Left click the  to advance the **Station** indicator to the end of the corridor.



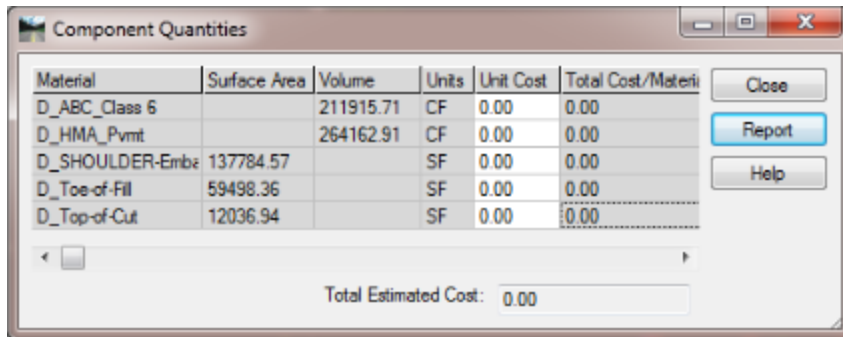
2. Left click the **Process All** button. If either step 1 or 2 are omitted, the quantity will not be correct for the corridor as a whole.



3. From the Roadway Designer menu bar, select **Tools > Component Properties**. This displays the **Component Properties** dialog box.

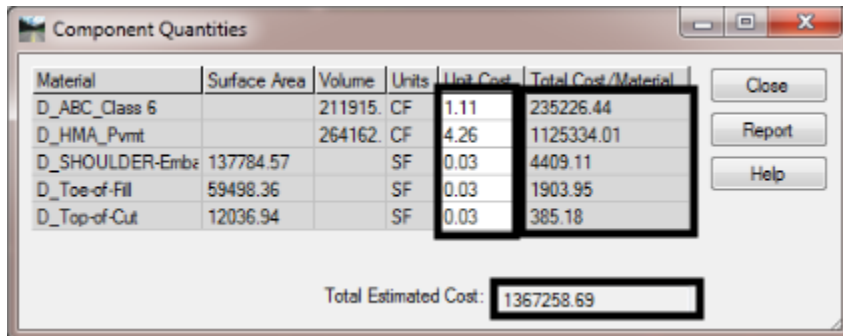


Note: that volumes are given in cubic feet and area is given in square feet.



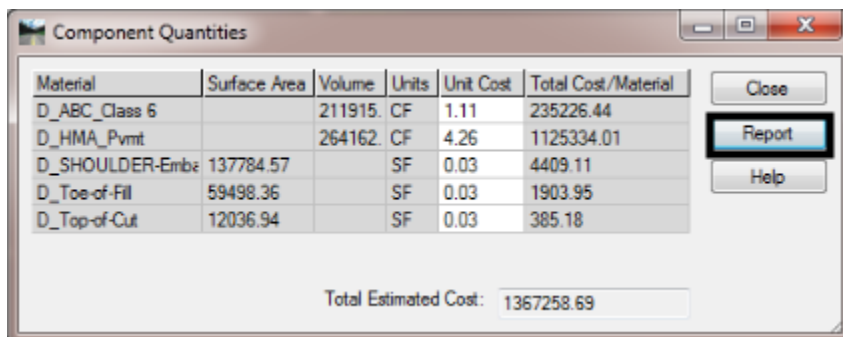
An estimated material cost can be generated entering a dollar amount in the unit cost field. Remember, unit costs may need to be converted to the appropriate unit (cubic feet for volumes and square feet for area).

- Key in the desired value in the **Unit Cost** field and press the **Tab** key to accept. The total estimated cost for the item and the grand total are automatically calculated.



An XML report of the estimated quantities can be created. The reports converts cubic feet to cubic yards but it leaves the area measurements in square feet.

- Left click the Report button. This displays the Bentley Civil Report Browser with the estimate data.



Below is an example of the report.

Roadway Designer Component Quantities Report							
				Report Created: 6/24/2015 Time: 1:26pm			
Corridor Name: SH 86 Mainline							
Alignment Name: SH 86							
Input Grid Factor: 1.000000				Note: All units in this report are in feet, square feet and cubic yards unless specified otherwise.			
Station	Material	Component End Area Totals		Component Surface Area Totals			
		Area	Volume	Length	Area	Unit Cost	Material Cost
203+80.28							
	D_Top-of-Cut:			12.21		0.03	0.00
	D_ABC_Class 6:	27.0				1.11	0.00
	D_SHOULDER-Embankment:			24.33		0.03	0.00
	D_HMA_Pvmt:	32.8				4.26	0.00
203+87.30							
	D_Top-of-Cut:			12.38	86.3	0.03	2.76
	D_ABC_Class 6:	27.0	7.0			29.97	210.36
	D_SHOULDER-Embankment:			24.33	170.8	0.03	5.47
	D_HMA_Pvmt:	32.8	8.5			115.02	979.32
203+90.00							
	D_Top-of-Cut:			12.43	33.5	0.03	1.07
	D_ABC_Class 6:	27.0	2.7			29.97	80.89
	D_SHOULDER-Embankment:			24.33	65.7	0.03	2.10
	D_HMA_Pvmt:	32.8	3.3			115.02	376.56
260+43.16							
	D_Top-of-Cut:					0.03	0.00
	D_ABC_Class 6:	39.0	4.6			29.97	136.89
	D_Toe-of-Fill:			6.13	19.1	0.03	0.61
	D_SHOULDER-Embankment:			24.33	76.9	0.03	2.46
	D_HMA_Pvmt:	48.8	5.7			115.02	656.73
Totals:							
	D_Top-of-Cut:				12036.9	0.03	385.18
	D_ABC_Class 6:		7848.7			29.97	235226.44
	D_Toe-of-Fill:				59498.4	0.03	1903.95
	D_SHOULDER-Embankment:				137784.6	0.03	4409.11
	D_HMA_Pvmt:		9783.8			115.02	1125334.01
						Total Estimated Cost:	1367258.69

3. Creating and Reviewing the Design Surface Model

The design model should be reviewed in a similar manner as the existing surface. The main difference in the models is that the design model has 3 dimensional components that define the pavement structure which is not present in the existing ground model.

a. Set up the Create Surface command

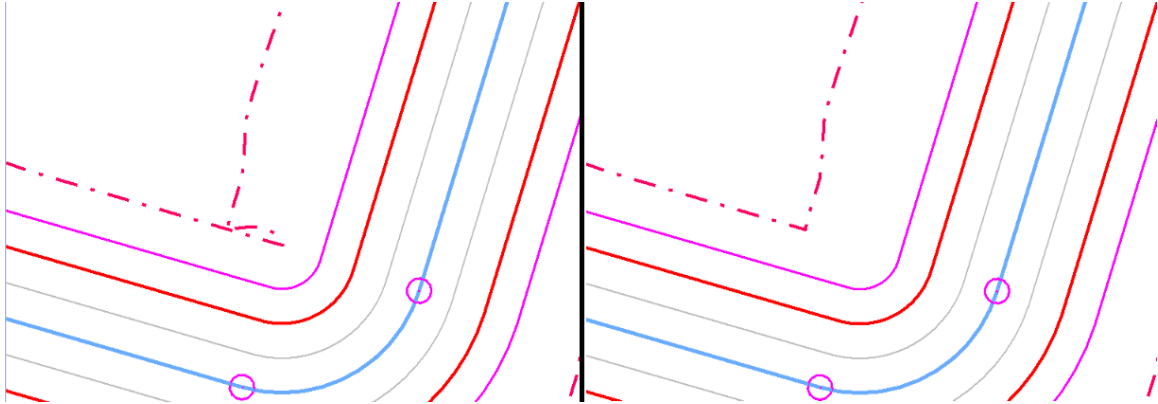
The last step in Roadway Designer is creating the design model. Understanding the options available in the Create Surfaces dialog box is key to getting an accurate design model. Design models created from a single corridor are straight forward. Creating a design model from multiple corridors can be a little more complex.

General Options – These are items that can be applied to any design model. Below is a brief explanation of each option.

- **New Surface for Each Corridor** – When on, all surfaces created are named using the corridor's name. The Name field is greyed out so that nothing can be entered in it. If multiple corridors are selected a design model for each corridor is created using only the data defined in that corridor.

When off, only one corridor is created. The user must enter a name in the Name field for the design model. If multiple corridors are selected the design model contains data from all corridors selected.
- **Empty Design Surface** – When on, if the design model being created uses the exact name of a surface currently loaded, the data in the loaded surface is deleted before the corridor(s) is processed. When off, the corridor data is added to the existing dtm.
- **Include Null Points** – When on, any Null Points defined in the template are added to the design model as untriangulated breaklines. Null Points are generally used as measuring devices for point controls and various point constraints and including them in the design model resulting in clutter.
- **Triangulate** – When on, the triangle mesh for the design model is computed and stored with the surface. When off the triangle mesh is not created. The triangles will have to be created before any view surface commands can be used.
- **Create Alternate Surfaces** – Alternate surfaces are created from points identified in the template. Any points within the template can be identified including points that are not normally triangulated. So, an alternate surface can be created to represent the top of grading for example. When on, the alternate surface(s) is created.
- **Process Visible Range Only** – When on, the corridor(s) is only processed to the extents that are visible in the plan view of Roadway Designer. When off, the entire corridor(s) is processed.

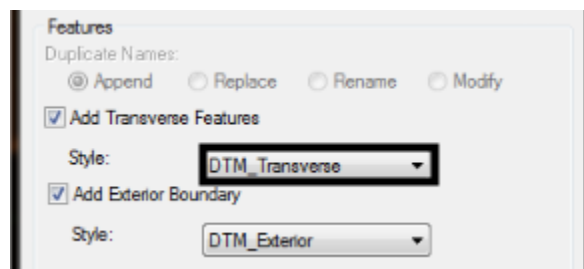
- **Remove Loops** – Loops in a surface are created when template drops overlap. This can occur on the inside of arcs with a small radius. This can cause problems with the triangulation of the design model. The illustration below shows a corridor with Remove Loops toggled off (left) and with Remove Loops toggled on (right).



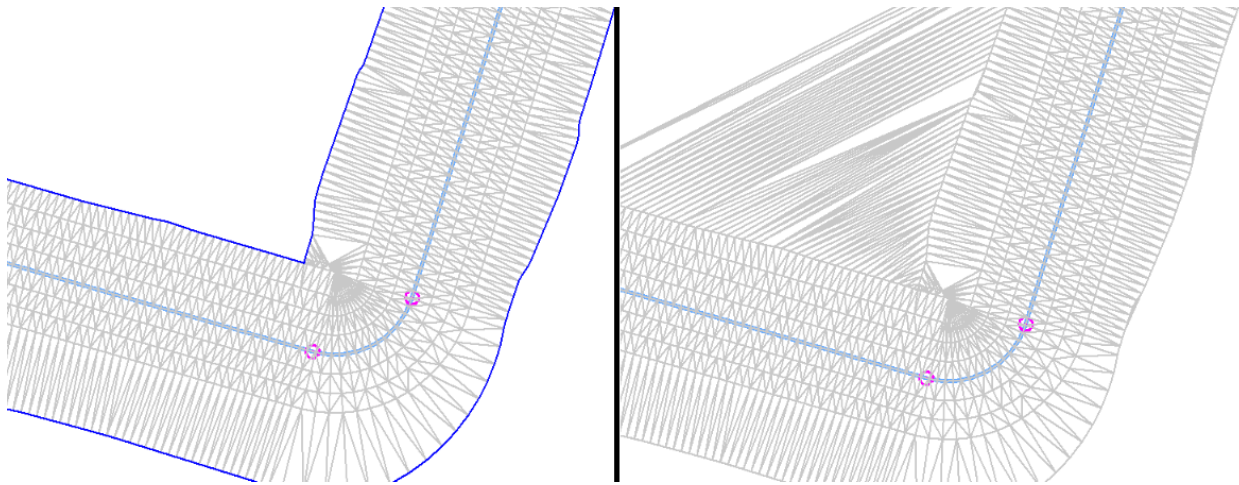
Features – The Create Surface command make liner breakline features out of every point (except null points) defined in the template. The Features area allow two other feature types to be added to the design model.

- **Add Transverse Features** – A transverse feature represents the design surface that is displayed in cross sections. When on, a transverse feature is created at each template drop. In most situations, transverse features are redundant and should not be used. However, in areas where side slope vary greatly and in intersections transverse features are very useful.

The **DTM_Transverse Style** is used when using this option. Transverse features are named after the template drop station where they occur.



- **Add Exterior Boundary** – An exterior boundary is used to contain triangles within the actual construction area. The boundary feature is given the name Exterior Boundary automatically. The **Style** used for the exterior boundary is **DTM_Exterior**. The illustration below shows the results of a design model using an exterior boundary (left) and the same model without the boundary (right). The extra triangles in the right image do not represent design data and will cause errors in volume calculations. Therefore, an exterior should always be used unless there is a specific reason not to use it.

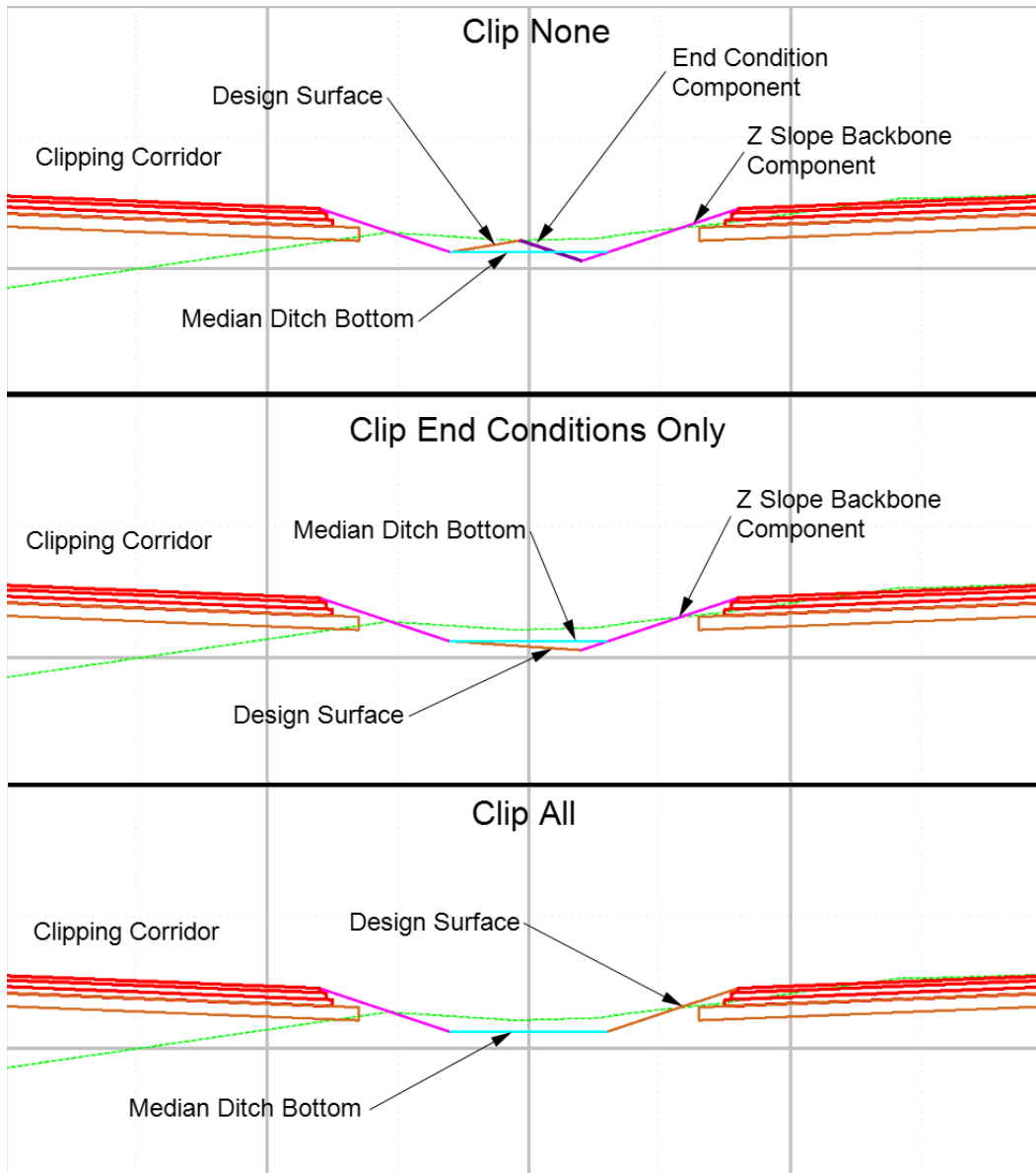


- **Duplicate Names** – When **Empty Design Surface** is toggled off additional data can be added to a model that already contains information. These options determine what happens to features/components with identical names are stored into the same model.
 - **Append** – The new data is added to the existing data creating a single feature/component. This may result in data being duplicated within the same area.
 - **Replace** – The existing feature/component is deleted and the new one is added to the model. This could result in the unwanted loss of data.
 - **Rename** - The new feature/component is renamed (usually by adding a “1” to the end of the name) and added to the model. This could result in two features with duplicate data.
 - **Modify** – This option modifies the existing feature/component by the new feature/component where the two are different. If the modifications to the corridor result in templates
- **Densify using Cord Height Tolerance** – When placing templates around a horizontal curve, points to the outside of the curve will be further apart than what is specified in the template drop interval. Vertical curves create a similar distortion, but for the full width of the template. This option is used to create additional data in areas of horizontal and/or vertical curves to reduce this distortion. Toggle on one or both options as desired.

- **Display in Plan View** – When the Create Surface command processing is complete the selected items are displayed in MicroStation. The items are displayed in 3D so that they are spatially correct.
 - **Features** – As the corridor is processed, template points with the same name are connected between each template drop. This creates the breakline features that define the model. When toggled on, these linear elements are displayed. This setting honors the Feature Filter setting, so if the Feature Filter Lock is on only features that pass through the filter will be displayed.
 - **Components** – As the corridor is processed, the features are connected together to form the components as defined in the template. This produces 3D solids of the surfacing material. When toggled on, these solids are displayed in MicroStation.
- **Create Surface(s) from** – This area is used to select the corridors that will be used to create design models. Corridors can be selected and processed one at a time or as a group. If multiple corridors are selected, the output is determined by the setting for **New Surface for Each Corridor**. If on, a new dtm is created for each corridor. If off, data from all of the selected corridors is stored in a single dtm.

To select a single corridor left click on the desired corridor name. To select multiple corridors hold the Ctrl key and left click on the desired corridor names. A group of consecutive corridors can be selected by left clicking on the first corridor, then holding the **Shift** key and left clicking on the last corridor. The **All** and **None** buttons can be used to select or deselect all of the corridors.

- **Corridor Clipping** - Clipping is the removal of overlapping components from a design model created from two or more corridors. In situations where two corridors are combined into a single model, One corridor, the clipping corridor, is used to determine which components are removed from the clipped corridor.
 - **Clipping Corridor** – Target Aliasing is used to determine which corridor is the Clipping Corridor. A corridor with aliasing that targets another corridor is the cutting corridor. The targeted corridor is subject to clipping.
 - **Targeted Corridor** – A corridor that has been selected as a target for another corridor is subject to clipping. Where components overlap between the Clipping and the Targeted corridors, the targeted corridor's components can be deleted based on the Clipping Option selected.
- **Clipping Options** – These specify what components can be removed from the targeted corridor. The available options are:
 - **Clip None** – All components from the targeted corridor are added to the design model.
 - **Clip End conditions Only** – End condition components that are partially of fully covered by the clipping corridor are removed from the model. All backbone components of the target corridor are added to the design model.
 - **Clip All** – All components that are partially of fully covered by the clipping corridor are removed from the model.

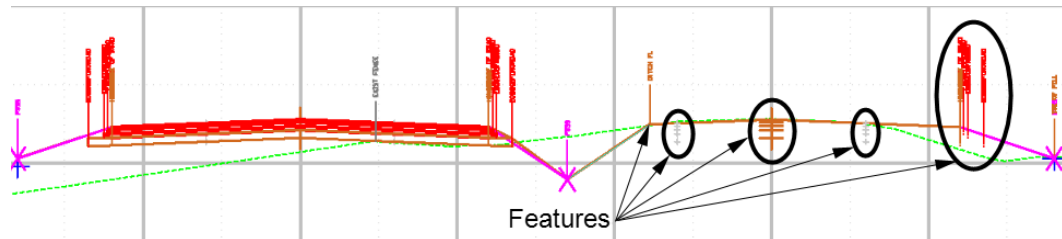


The example above shows the same template drop showing all three clipping options. The top illustration shows the results of the Clip None option. Notice that the design ground line is attached to the end condition of the targeted corridor. When Target Aliasing is used the targeted corridor must be processed first in order for the Clipping Corridor to have something to hit. Because the end condition and the Z Slope components of the targeted corridor were initially triangulated, they retain that setting in the combined surface resulting in the design surface following those features.

The middle illustration shows the Clip End Conditions Only option. Notice that the end condition component of the Targeted Corridor is gone. The Z Slope is a backbone component so it is retained and used to create the triangulated surface.


The bottom illustration shows the Clip All option. Because the end condition and the Z Slope components are both removed, the design surface extends from the end of the Clipping Corridor, the Median Ditch Bottom, then to the left edge of pavement of the target corridor.

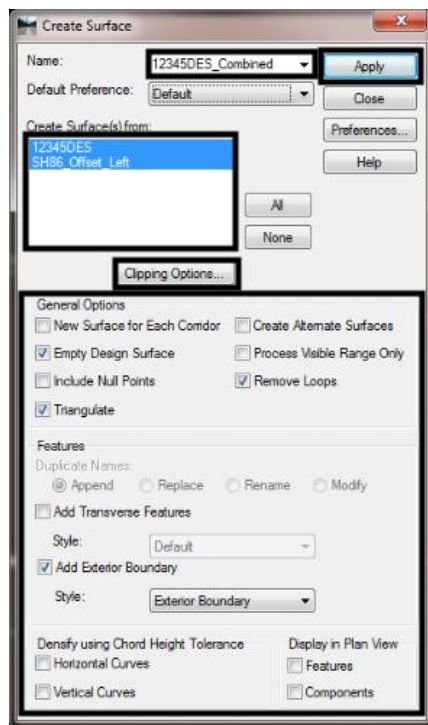
Any features that are overlapped by the Clipping Corridor will be deleted based on the Clipping Option selected. Features of deleted components that are not overlapped are retained in the design surface and may be used for triangulation of the combined surface. The illustration below shows a cross section of a combined corridor surface where the Clipping Corridor overlaps into the Targeted Corridor's surfacing components. Even though the surfacing components have been deleted, the features have not.



To prevent the unwanted deletion of surfacing components, additional templates with vertical edges where the corridors merge. Also, point controls should be defined so that the corridors meet but do not cross each other.

Creating The Design Surface - To create the design surface:

1. Select **Create Surfaces** from the **Corridor** dropdown menu or from the button bar . This displays the **Create Surfaces** dialog box.
2. Key in the desired surface **Name**, if needed.
3. Select the corridors from the **Create Surface(s) from** area and set the **Clipping Options**.
4. Make the desired **General Option**, **Features**, **Densify**, and **Display** settings.
5. Left click the Apply button. This executes the command and creates the design model(s).

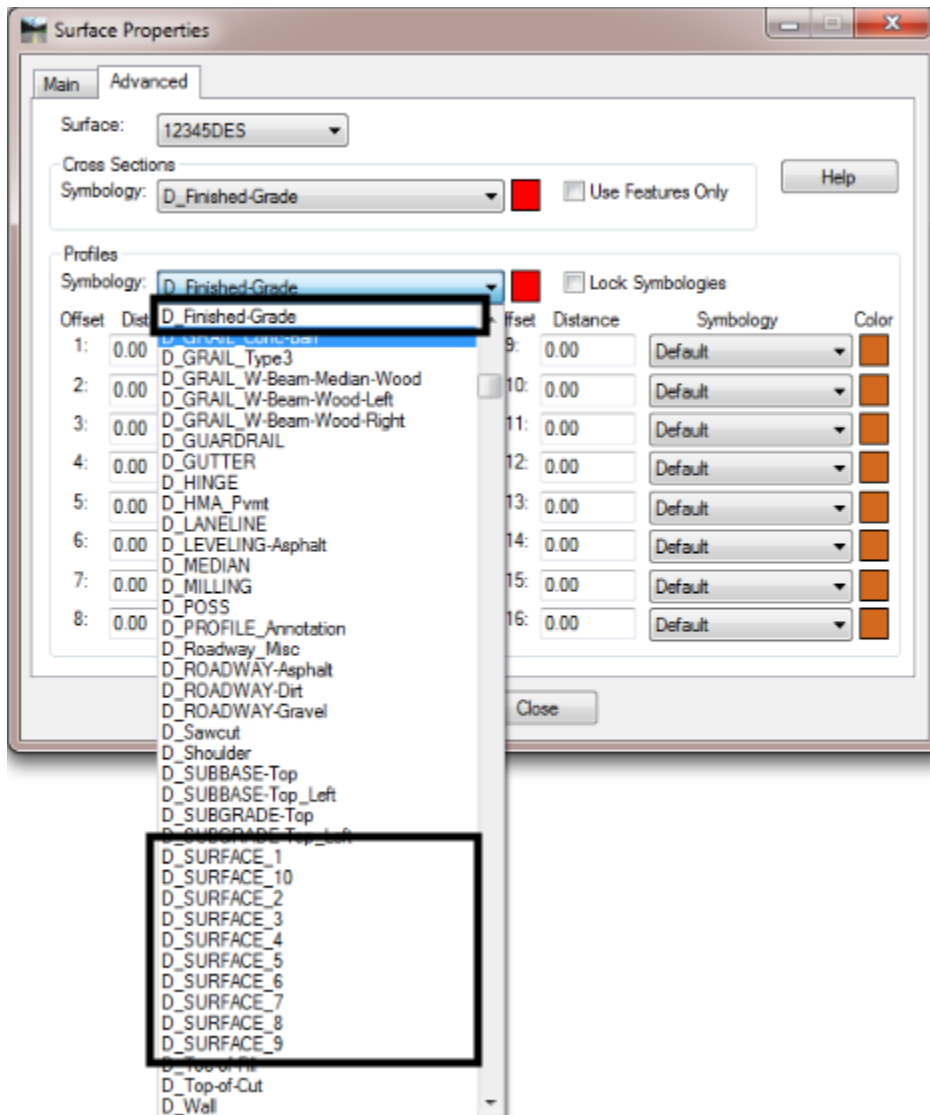


b. Review design surface Properties

This is done in the same manner as 1.a above.

1. Right click on the surface name in the InRoads Explorer and select **Properties** from the list.
2. In the **Surface Properties** dialog box, review the **Data Range** area. Look for entries that seem abnormal for the area of the project. The most common and easily recognizable issue is a zero minimum elevation. There should be no zero elevations in the design surface.

- Left click on the **Advanced** tab. The **Cross Sections** and **Profiles Symbology** should be set to **D_Finished-Grade** or **D_Surface.#** (the # represents the numbers 1 through 10). The **D_Finished-Grade** is used to represent the mainline surface. The **D_Surface_#** symbologies are used for all other design surfaces. Use the drop down menus to select the appropriate symbology for the surface. Use the same style for both **Cross Section** and **Profile** symbology.



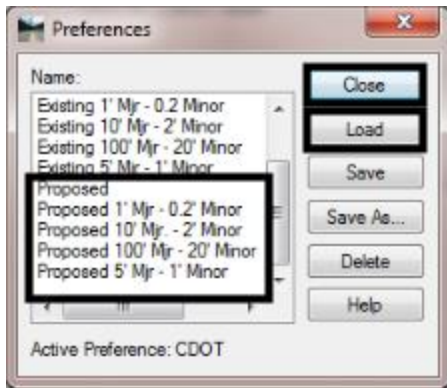
- Left click the **Apply** button to accept the changes. Left click **Close** to dismiss the dialog box.

c. Review design surface Contours

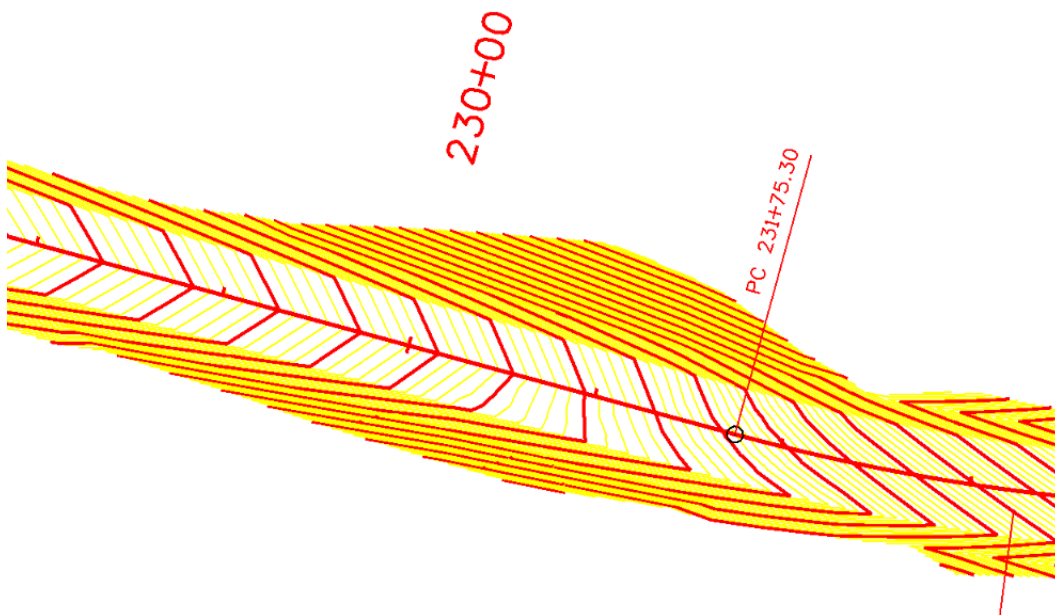
To display contours of the design model surface:

- From the InRoads menu bar, select **Surface > View Surface > Contours**. This displays the **View Contours** dialog box.

2. In the **View Contours** dialog box, left click the **Preferences** button. This displays the **Preferences** dialog box. Preferences are used to determine how the contours are displayed in MicroStation. There are several **Proposed** preferences that are available. These are used for displaying contours of design surfaces so that they can be distinguished from existing ground contours.
3. Highlight the desired preference from the list then left click the **Load** button followed by the **Close** button.



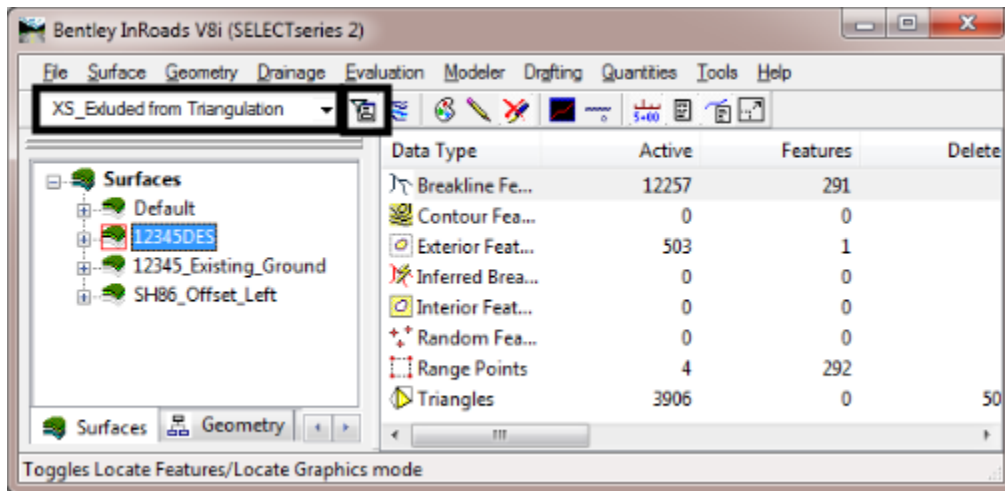
The same logic applies to design model cross sections as it does to existing ground cross sections. Use an interval that provides enough information without obscuring other important information. The illustration below shows an example of design model contours as the roadway transitions from the standard template on the left to a superelevated template on the right.



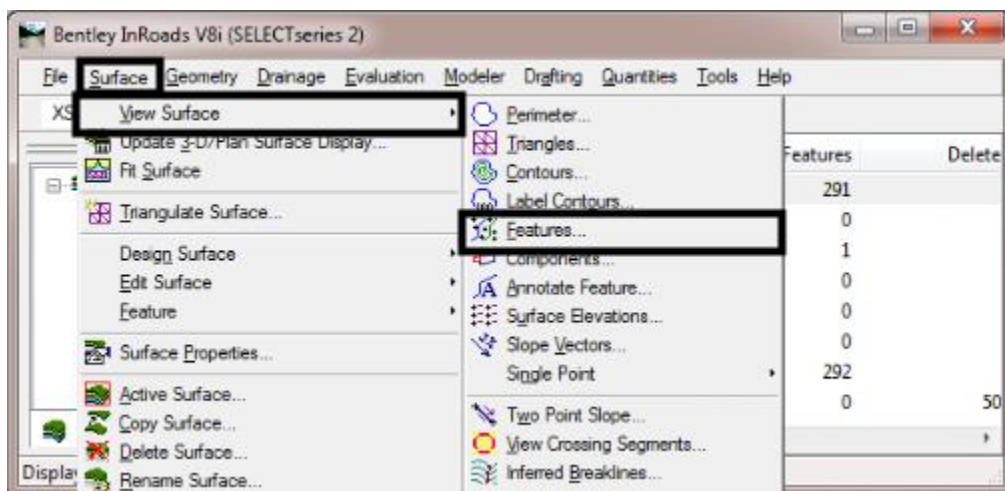
d. Review design surface Topo

Most anomalies in the design model should have been taken care of before the surface was created. However, some of these anomalies may not be clearly identifiable within Roadway Designer. Reviewing the triangulated features of the design surface provides another chance to locate these anomalies. To view the triangulated design features:

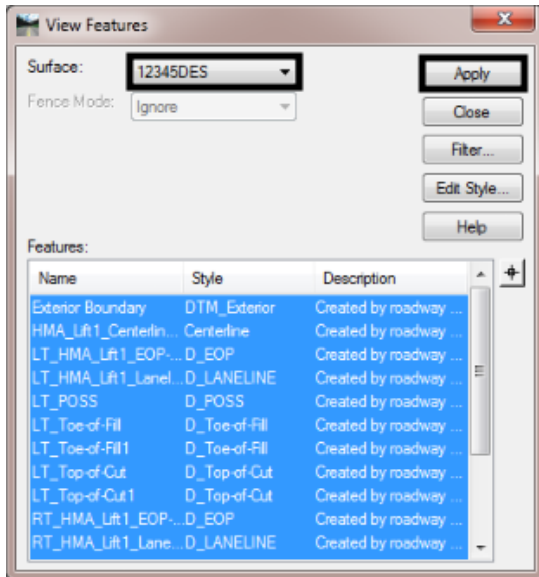
1. From the InRoads **Locks** toolbar, select the feature filter **XS Excluded from Triangulation**. This filter only allows triangulated features to be displayed.
2. Toggle on the **Feature Filter Lock**. This activates the filter so that it is used.



3. From the InRoads main menu, select **Surface > View Surface > Features**. This displays the **View Features** dialog box.

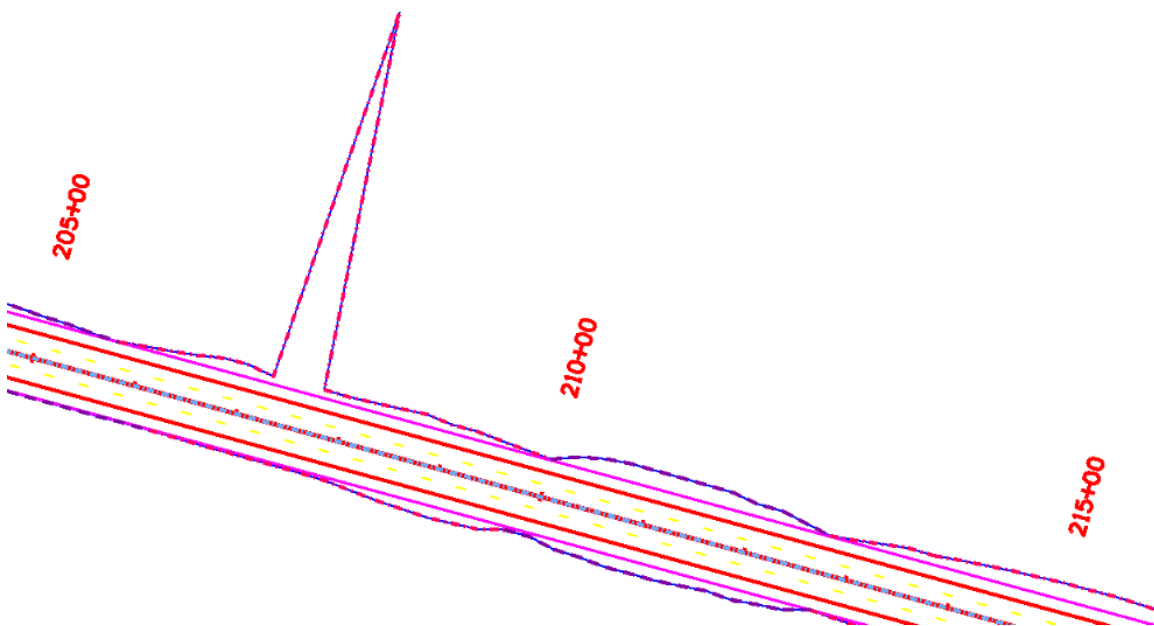


4. In the **View Features** dialog box, verify that the **Surface** is set to the design model.
5. By default, all of the features are selected. Left click the **Apply** button to activate the command.



6. Left click the **Close** button to dismiss the **View Features** dialog box.

The illustration below shows an example of an anomaly in the design model. In this case, a single toe of slope extends far past the surrounding data. Viewing the design model feature data in conjunction with the survey TOPO can help to determine if the anomaly is caused by an existing terrain element (like a creek channel) or if its and issue with either the corridor path (horizontal and/or vertical alignment) or the template design.



If the problem is with a design element (template or alignment, for example) fix the element, update the corridor with the fixes, and re-create the design model. If the issue is legitimate, then some modifications to the corridor can eliminate or reduce the severity of the anomaly. Depending on the problem, some options include End Condition Overrides, Point Controls, and Single Station Edits.

4. Comparing Existing Surface and Design Models Data

The final steps to complete the QA process are to compare the design model to the existing ground. This helps to determine the feasibility of the design and can be used to maximize efficiency. In order to ensure consistency between electronic data and plan set data, End Area Volumes (included in the plan set) need to be compared to Triangle Volumes (electronic data). Because Triangle Volumes only use the triangulated surface data from the existing and design models, the cross sections used to compute end area volumes must also only contain triangulated data. That means the Component display must be turned off. Once it has been verified that the end area volumes are within the tolerances when compared to the triangle volumes, surfacing and other data can be added to the cross sections and final end area volumes can be calculated.

a. Cross Section set-up

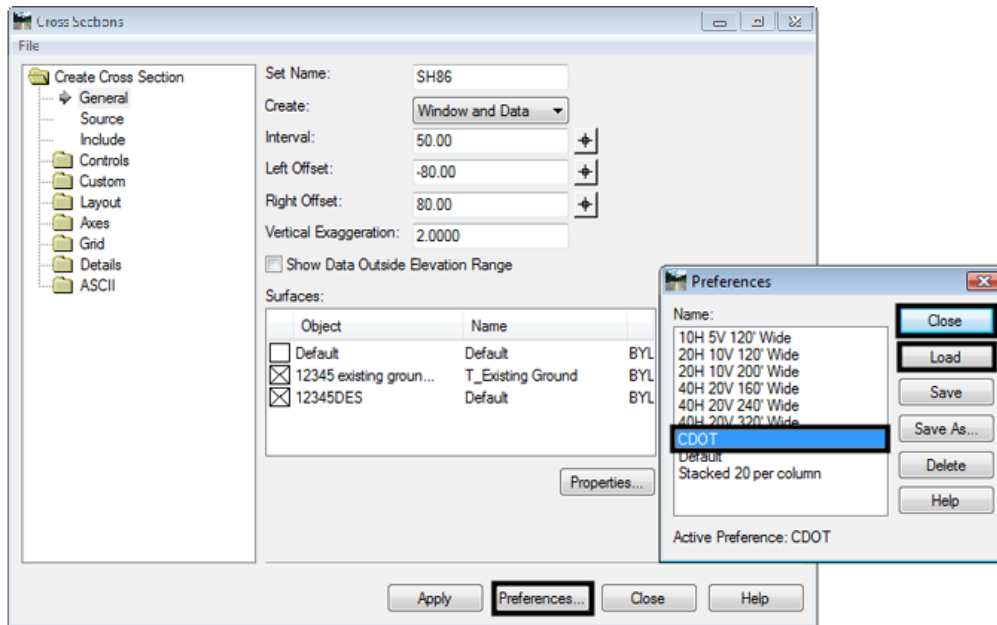
Cross sections have been one of the standard tools for evaluating designs for decades. The advantage of using cross sections for earthwork quantities is that the quantities are checkable by hand. The disadvantage of using cross sections for earthwork quantities is that not all of the data is used to compute the volumes.

In order to maximize the data used and the accuracy of the computations, cross sections should be generated in the same locations as the template drops in Roadway Designer.

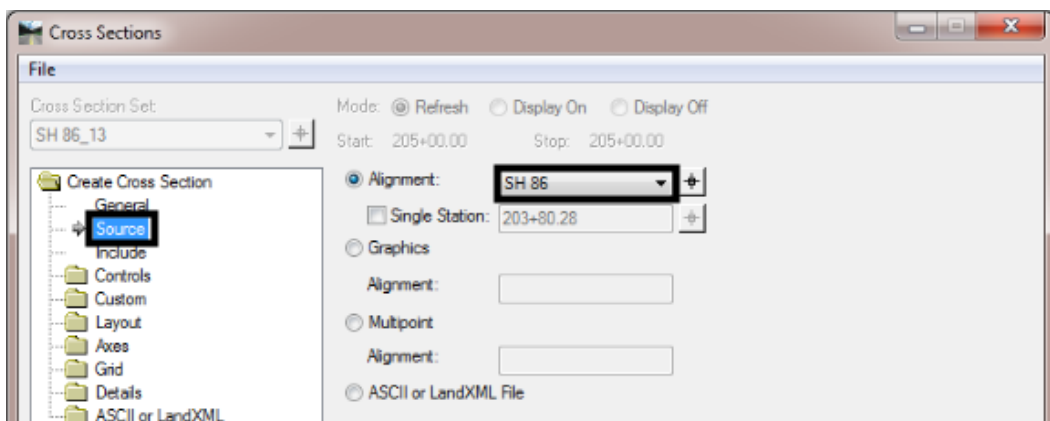
To set up cross sections to match Roadway Designer template drops:

6. Select **Evaluation > Cross Section > Cross Sections** from the InRoads bar menu. This displays the **Cross Sections** dialog box.
7. From the **Cross Sections** dialog box, left click the **Preferences** button. This displays the **Preferences** dialog box that is associated with Cross Sections.
8. From the **Preferences** dialog box, highlight the desired preference and left click **Load**.

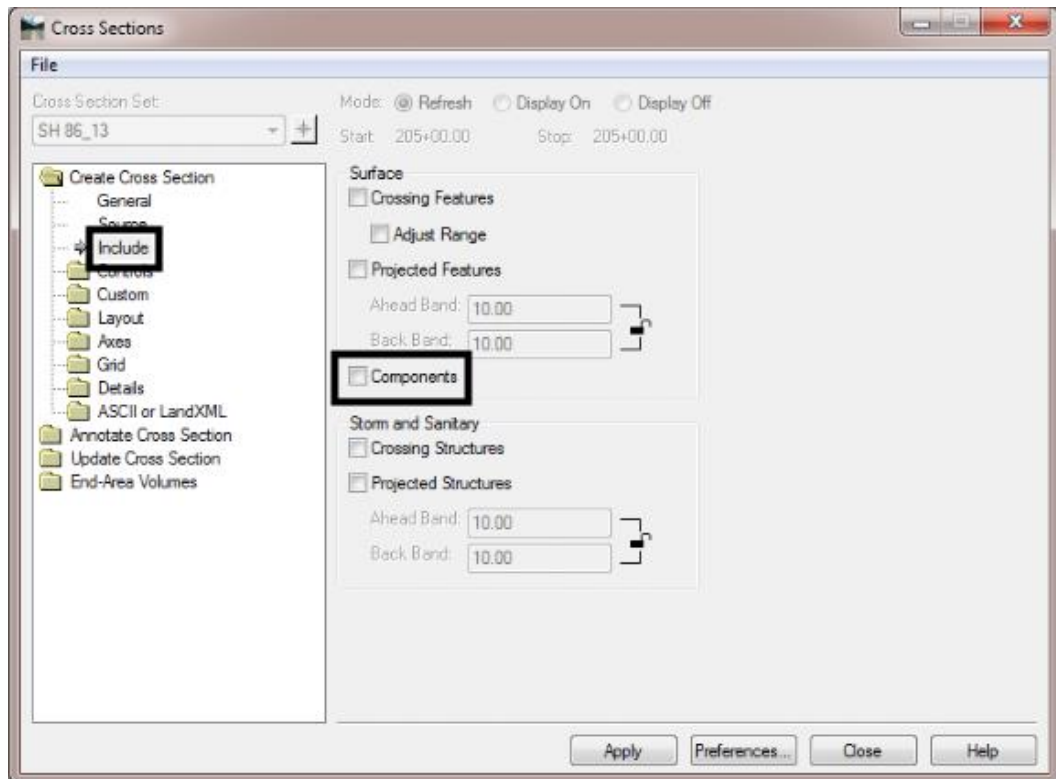
- Left click **Close** to dismiss the **Preferences** dialog box.



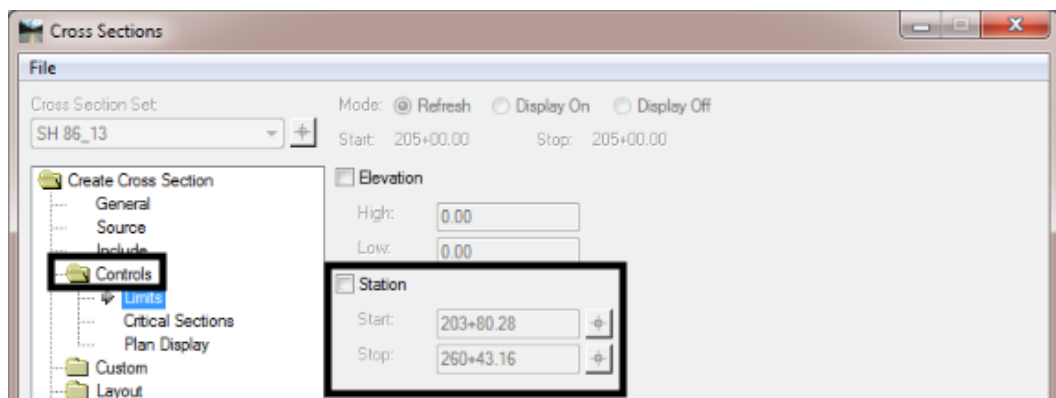
- Change the **Interval** to match that used in the corridor that is being cross sectioned.
- Set the **Left Offset** and **Right Offset** values to ensure that the entire width of the design surface is visible within the cross section window.
- Select the **Source** leaf and verify that the correct alignment is selected.



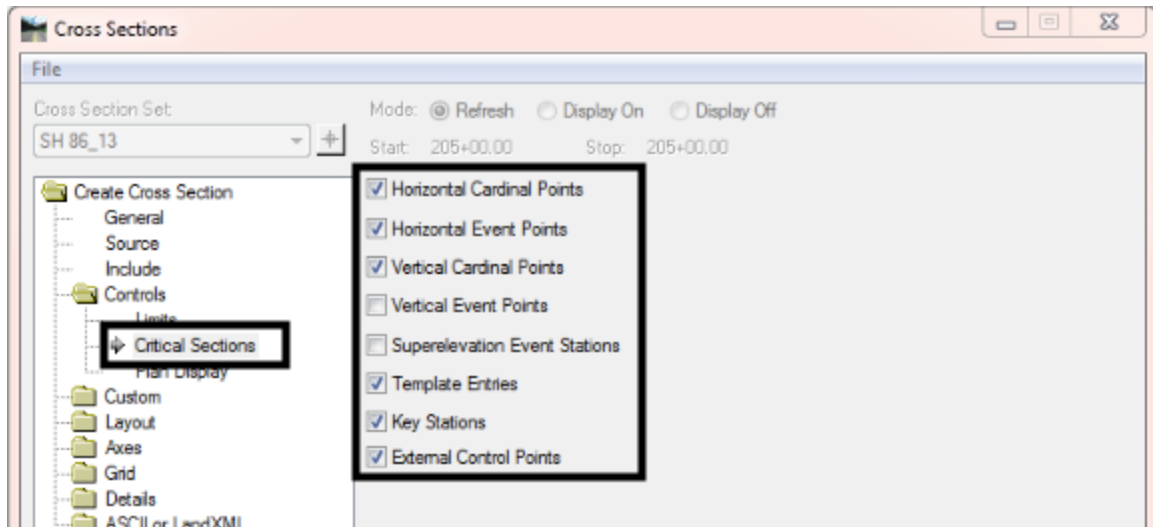
13. Select the **Include** leaf. Toggle off **Components**. This ensures that the data used for end area volumes is the same as that used for triangle volumes.



14. Expand the **Controls** folder. Set the Limits as needed.

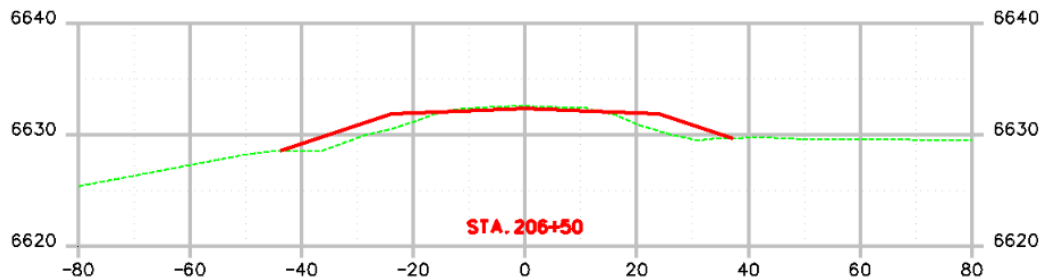


15. Select the **Critical Sections** leaf. Toggle on the same items that were used in Roadway Designer.



Note: Typically **Event Points** are assigned to the horizontal geometry. If event points have been assigned to the vertical geometry toggle them on as well. Also, **Superelevation Event Stations** are legacy data from when superelevation was stored as part of the horizontal geometry so toggling it on will have no effect on the cross sections. Superelevation stations in the current version are **External Control Points** and can be included in the cross section set by toggling that option on.

16. Left click the **Apply** button then left click the location for the cross sections. This creates a cross section set. Below is an example of what a cross section will look like. Notice that there are no surfacing components displayed.

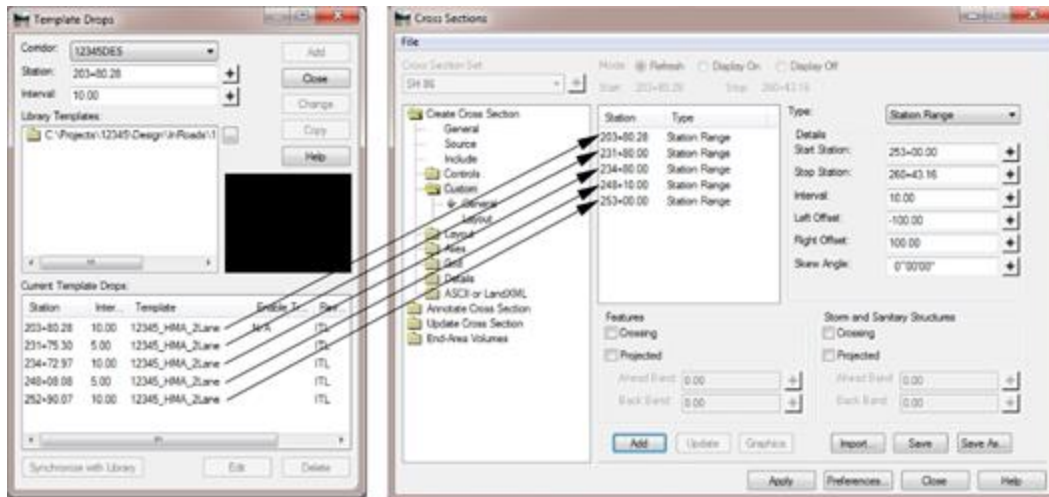


If multiple template drop intervals were used in the corridor, these can be matched using a custom cross section definition. Only cross sections that are perpendicular to the source alignment are used to calculate volumes. When creating a custom cross section set for volumes, use only the **Station Range** and **Perpendicular** options. To create a custom cross section definition:

1. Expand the **Custom** folder, this displays the custom cross section leaf.
2. Set the **Type** to **Station Range**.
3. Set the **Start Station** to that of the first template drop.

4. Set the **Stop Station** to that of the next template drop.
5. Set the **Interval** to that used for the first template drop.
6. Set the **Left Offset** and **Right Offset** to a value that allows the entire design surface width to be displayed.
7. Left click the **Add** button. This creates the entry for that station range.
8. Set the **Start Station** to one interval past the beginning of the second template drop. In the example below, the second template drop is at 231+75.30 and the interval for the second template drop is 5 feet. The Start Station is rounded to the nearest 5 foot past the template drop entry, so **231+80.00** is entered.
9. Repeat steps 4 through 9 until all of the template drops are used. Note, the Stop Station for the last station range is that for the end of the project.

The illustration below shows the Template Drops dialog box from Roadway Designer (left) along with the custom cross sections leaf (right). The arrows point from the template drops to the corresponding cross section station ranges.



Custom cross section sets honor **Critical Stations** listed under the **Controls** leaf, so all of the cardinal points, event points, and external control points will be included in the set without having to enter them separately.

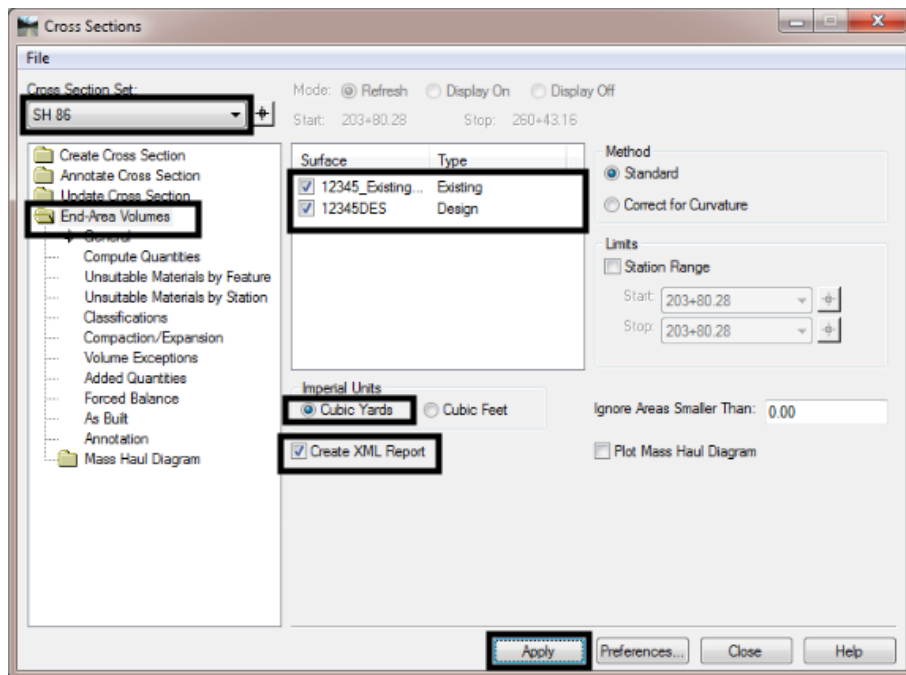
10. Once all the custom entries are made, left click the **Apply** button to create the cross sections.

b. End Area Volume set-up

When generating end area volumes to compare to the triangle volumes, only the basic settings that are found on the General leaf will be used. To compute end area volumes:

1. Select **Evaluation > Cross Section > Cross Sections** from the InRoads bar menu. This displays the **Cross Sections** dialog box.

2. Verify that the desired **Cross Section Set** is selected. If one was created, this should be the custom cross section set that matches the template drops in Roadway Designer.
3. From the **Cross Sections** dialog box, expand the **End-Area Volumes** folder. This displays the end area volumes **General** leaf.
4. Verify that the correct existing surface and the correct design surface are selected.
5. In the **Imperial Units** area, toggle on **Cubic Yards**.
6. Toggle on **Create XML Report**. This report contains the data that will be compared to the triangle volumes.
7. Left click the **Apply** button to execute the command.



The **Bentley Civil Report Browser** is displayed containing the **End Area Volume Report**.

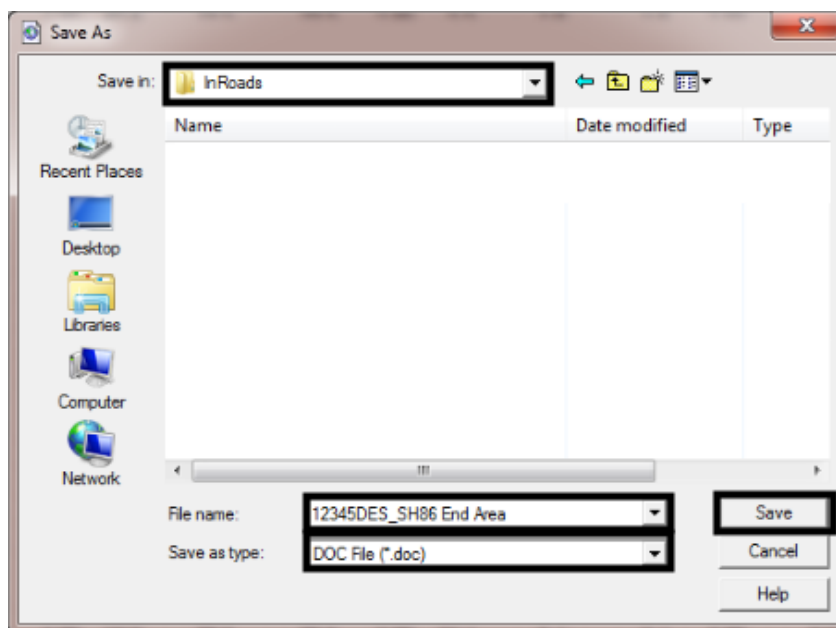
Station	Cut				Fill				Mass Ordinate
	Factor	Area	Volume	Adjusted	Factor	Area	Volume	Adjusted	
203+80.28	1.00	65.7	0.0	0.0	1.00	7.4	0.0	0.0	0.0
203+87.30	1.00	64.8	17.0	17.0	1.00	7.3	1.9	1.9	15.1
203+90.00	1.00	64.5	6.5	6.5	1.00	7.3	0.7	0.7	20.8
204+00.00	1.00	63.6	23.7	23.7	1.00	7.2	2.7	2.7	41.8
204+10.00	1.00	63.6	23.6	23.6	1.00	7.3	2.7	2.7	62.7
204+20.00	1.00	63.5	23.6	23.6	1.00	7.3	2.7	2.7	83.5
204+30.00	1.00	63.0	23.4	23.4	1.00	7.3	2.7	2.7	104.3

- Scroll to the bottom of the report. The illustration below identifies the columns of interest.

259+00.00	1.00	7.1	2.9	2.9	1.00	44.3	15.5	15.5	1.00	0.0	0.0	1.00	0.0	0.0	-20170.4
259+10.00	1.00	6.3	2.5	2.5	1.00	44.9	16.5	16.5	1.00	0.0	0.0	1.00	0.0	0.0	-20184.4
259+20.00	1.00	7.4	2.5	2.5	1.00	43.5	16.4	16.4	1.00	0.0	0.0	1.00	0.0	0.0	-20198.3
259+30.00	1.00	8.9	3.0	3.0	1.00	42.2	15.9	15.9	1.00	0.0	0.0	1.00	0.0	0.0	-20211.1
259+40.00	1.00	10.6	3.6	3.6	1.00	40.9	15.4	15.4	1.00	0.0	0.0	1.00	0.0	0.0	-20222.9
259+50.00	1.00	13.7	4.5	4.5	1.00	39.7	14.9	14.9	1.00	0.0	0.0	1.00	0.0	0.0	-20233.3
259+60.00	1.00	15.5	5.4	5.4	1.00	38.6	14.5	14.5	1.00	0.0	0.0	1.00	0.0	0.0	-20242.4
259+70.00	1.00	15.5	5.7	5.7	1.00	37.8	14.2	14.2	1.00	0.0	0.0	1.00	0.0	0.0	-20250.8
259+80.00	1.00	15.6	5.8	5.8	1.00	36.8	13.8	13.8	1.00	0.0	0.0	1.00	0.0	0.0	-20258.9
259+90.00	1.00	15.7	5.8	5.8	1.00	35.6	13.4	13.4	1.00	0.0	0.0	1.00	0.0	0.0	-20266.5
260+00.00	1.00	15.7	5.8	5.8	1.00	34.1	12.9	12.9	1.00	0.0	0.0	1.00	0.0	0.0	-20273.6
260+05.77	1.00	15.7	3.4	3.4	1.00	33.2	7.2	7.2	1.00	0.0	0.0	1.00	0.0	0.0	-20277.4
260+10.00	1.00	15.6	2.5	2.5	1.00	32.9	5.2	5.2	1.00	0.0	0.0	1.00	0.0	0.0	-20280.1
260+20.00	1.00	15.0	5.7	5.7	1.00	33.5	12.3	12.3	1.00	0.0	0.0	1.00	0.0	0.0	-20286.7
260+30.00	1.00	14.6	5.5	5.5	1.00	34.0	12.5	12.5	1.00	0.0	0.0	1.00	0.0	0.0	-20293.8
260+40.00	1.00	14.1	5.3	5.3	1.00	34.6	12.7	12.7	1.00	0.0	0.0	1.00	0.0	0.0	-20301.2
260+43.16	1.00	14.0	1.6	1.6	1.00	34.8	4.1	4.1	1.00	0.0	0.0	1.00	0.0	0.0	-20303.6
Grand Total:			4829.0	4829.0			25132.5	25132.5		0.0	0.0	0.0	0.0	0.0	

For the cut and fill totals, the left entry is the normal quantity and the right entry is the adjusted quantity. Because no adjustments were made the values are the same.

- In the **Bentley Civil Report Browser**, select **File > Save As** from the menu bar. This displays the **Save As** dialog box.
- In the **Save As** dialog box, navigate to the appropriate project folder.
- Set the **Save as type** to **DOC File (*.doc)**.
- Key in the desired **File name**.
- Left click the Save button to create the report file and dismiss the **Save As** dialog box.



- Close the **Bentley Civil Report Browser**.

The end area volume report file will be referred to when comparing the end area volumes to the triangle volumes.

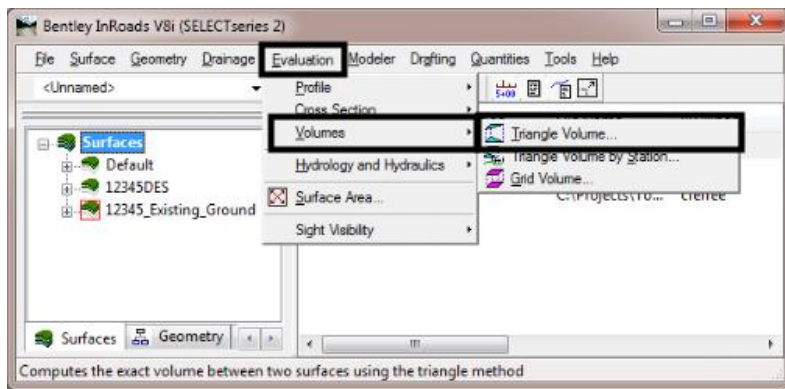
c. Generating Triangle Volumes

Triangle volumes are the most accurate measurement available. This is because the command compares the whole existing surface to the whole design surface with no interpolation and minimum rounding in the calculations. The disadvantages to triangle volumes are:

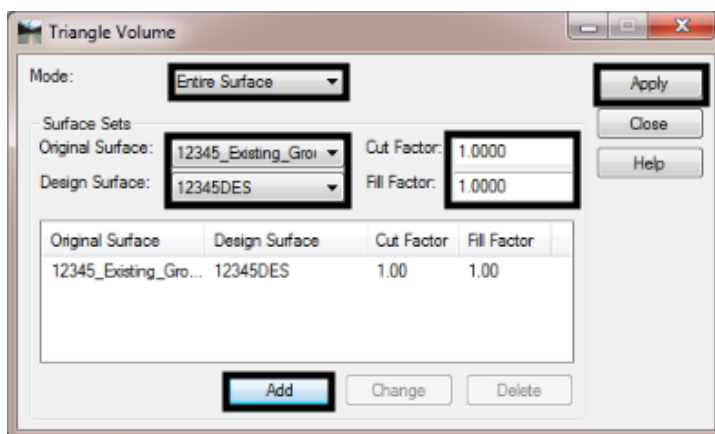
- There is no way to manually check the quantity
- They do not account for surfacing material

However, if the end area volumes calculated above and the triangle volumes are within the tolerances, then we can be confident that the end area volumes accounting for surfacing material will be accurate. To compute Triangle Volumes:

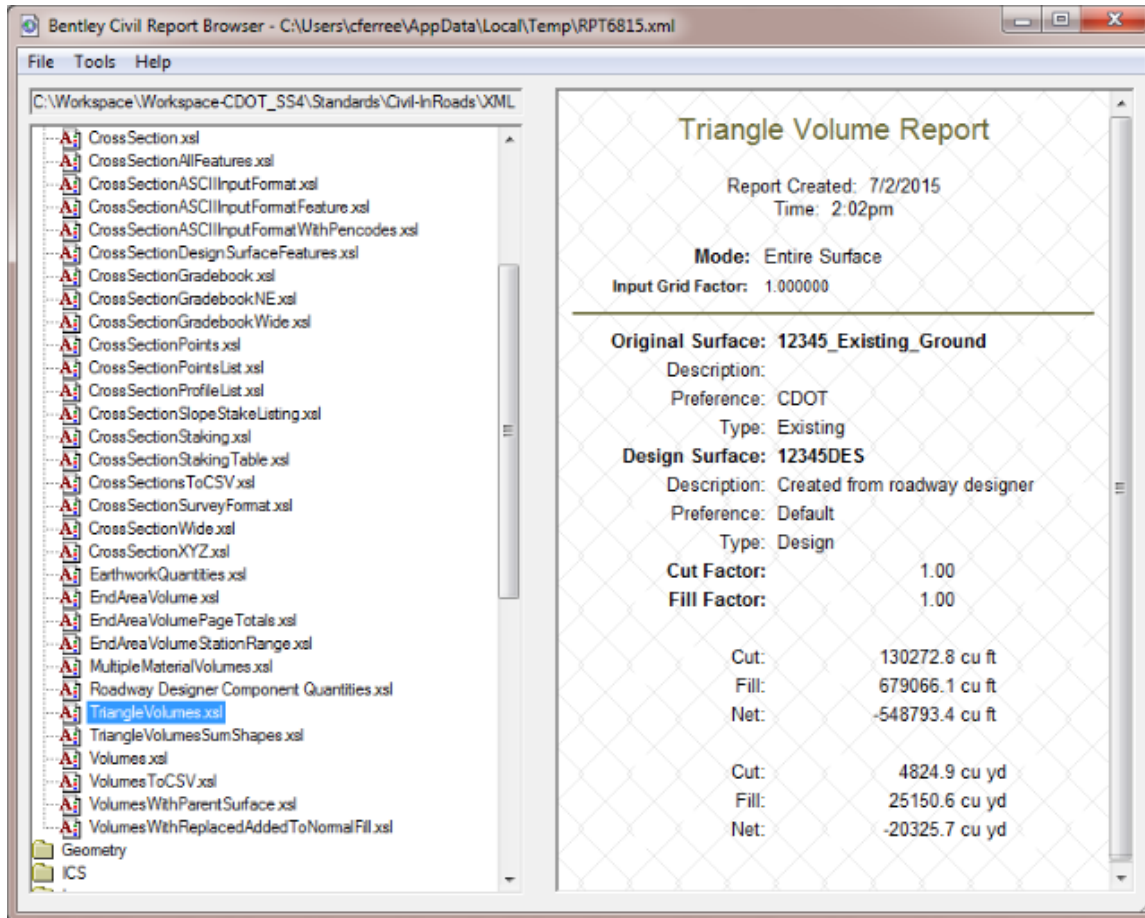
1. From the InRoads main menu, select **Evaluation > Volumes > Triangle Volume**. This displays the **Triangle Volume** dialog box.



2. In the **Triangle Volume** dialog box, set the **Mode** to **Entire Surface**.
3. Set the **Original Surface** to the existing ground surface for the project.
4. Set the **Design Surface** to the design model that is being evaluated.
5. Verify that the **Cut Factor** and **Fill Factor** are set to **1.00**.
6. Left click the **Add** button. This puts the data into the “to be processed” list.
7. Left click the **Apply** button. This computes the volumes and displays the results in the **Bentley Civil Report Browser**

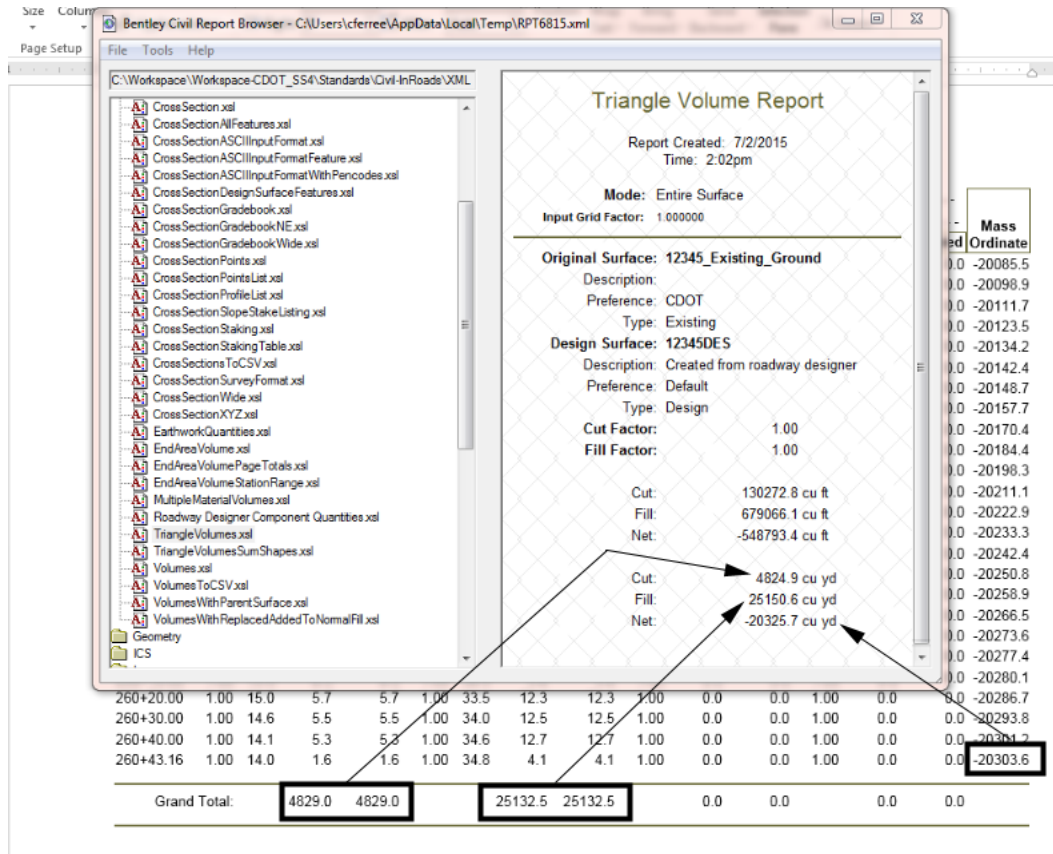


The illustration below is an example of the **Triangle Volume** report.



d. Comparing Triangle Volumes to End Area Volumes

To compare the two volume totals, simply open both reports and compare the like categories. The illustration show which items to compare.

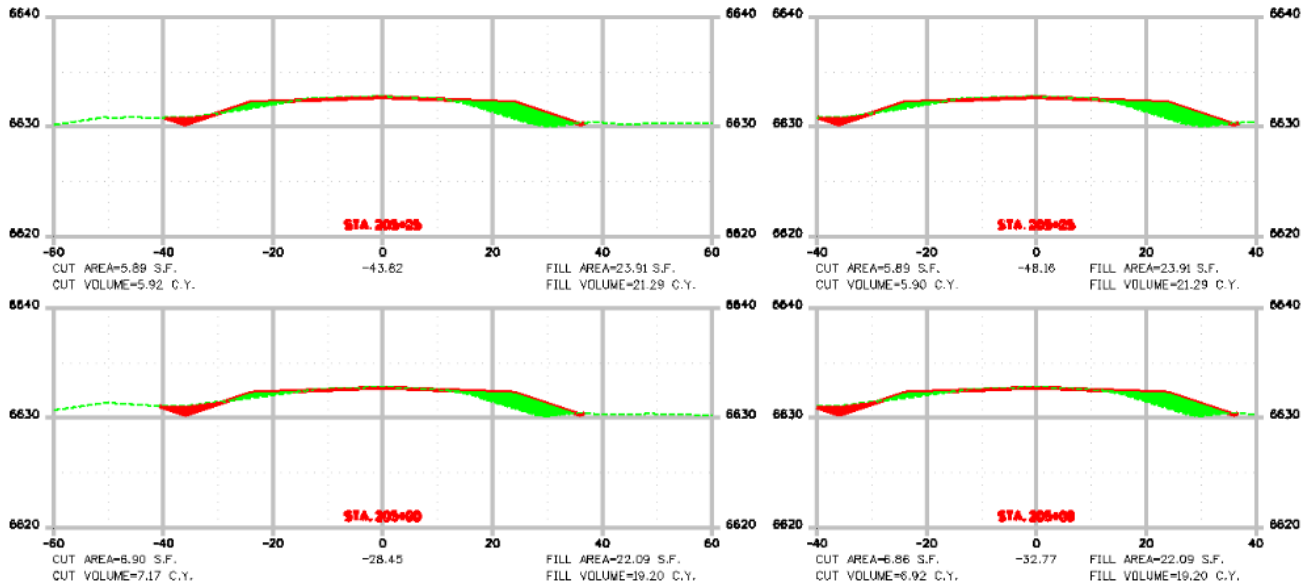


The chart below shows the comparison of the end area and triangle volumes from the illustration above.

	End area Volume	Triangle Volume	Difference in Cubic Yards	Percent Difference
Cut	4829.0	4824.9	4.1	0.08%
Fill	25132.5	25150.6	18.1	0.07%
Net	-20303.6	-20325.7	22.1	0.1%

If the differences in volumes falls outside the acceptable range, it must be determined where the differences occur. Start by reexamining the cross sections. One common error is to use an offset that is too narrow for the design data. The illustration below shows two sets of cross sections using

the same data. The left cross sections are wide enough to display the entire design model, the right cross sections are not. While the differences on a single cross section may not be great, that can add up quickly, especially on a long project.



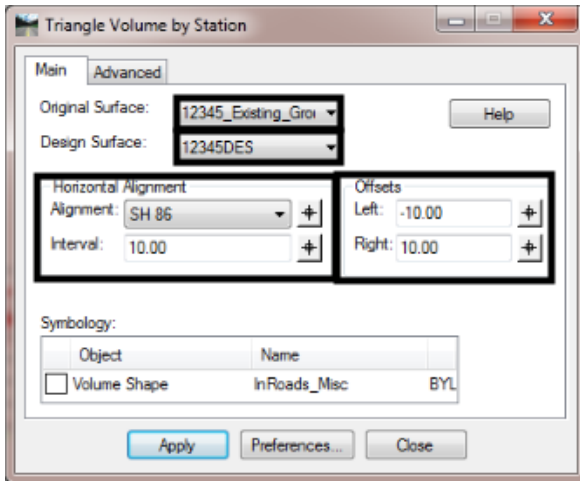
If the cross sections are complete then another cause for the discrepancy must be found. One option is to compare the end area volumes with the **Triangle Volume By Station** report. The **Triangle Volume By Station** report Breaks down the triangle volumes to user specified intervals. This can then be compared to the **End Area Volume** report to find where the problem is. To create a **Triangle Volume By Station** report:

1. From the InRoads main menu bar, select **Evaluation > Volumes > Triangle Volume by Station**. This displays the **Triangle Volume by Station** dialog box.



2. In the **Triangle Volume by Station** dialog box, on the **Main** tab, set the **Original Surface** to the existing ground surface.

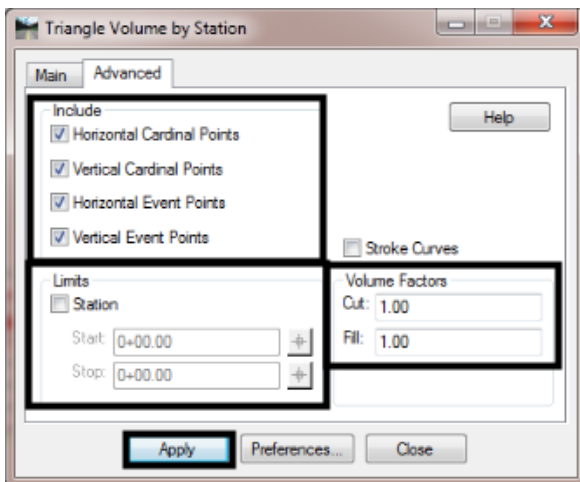
3. Set the **Design Surface** to the design model in question.
4. Set the **Alignment** to the one used to create the cross sections that the End Area Volume report was taken from.
5. Set the **Interval** to that used to create the cross sections.
6. Set the **Offsets** to a value that will ensure that all design data is within the offset limits.



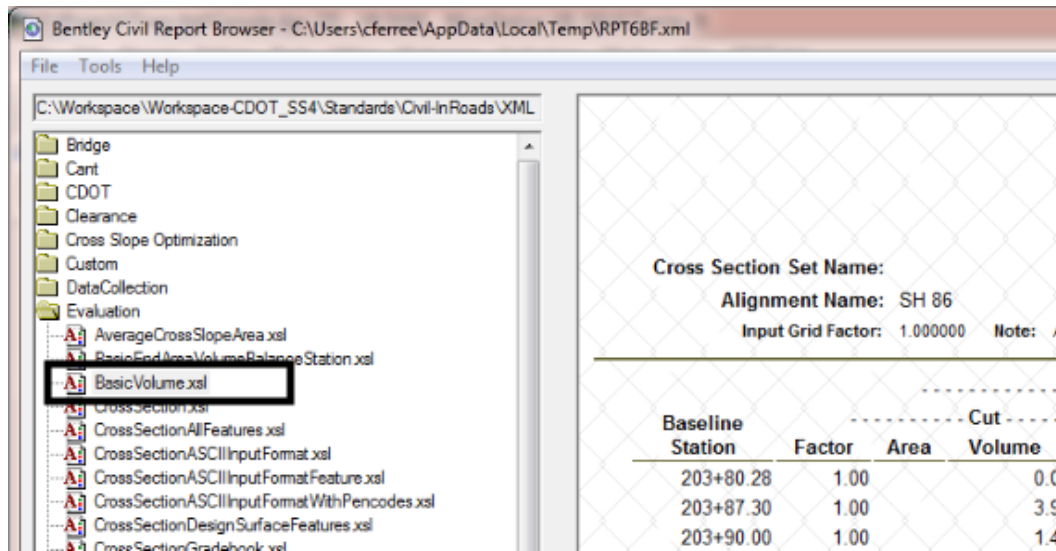
7. Select the **Advanced** tab.
8. On the **Advanced** tab, in the **Include** area, set the **Cardinal** and **Event** points as they were when the cross sections were generated.

If multiple template drop intervals were used in creating the design model, then the Triangle Volume by Station command will need to be run for each template drop interval.

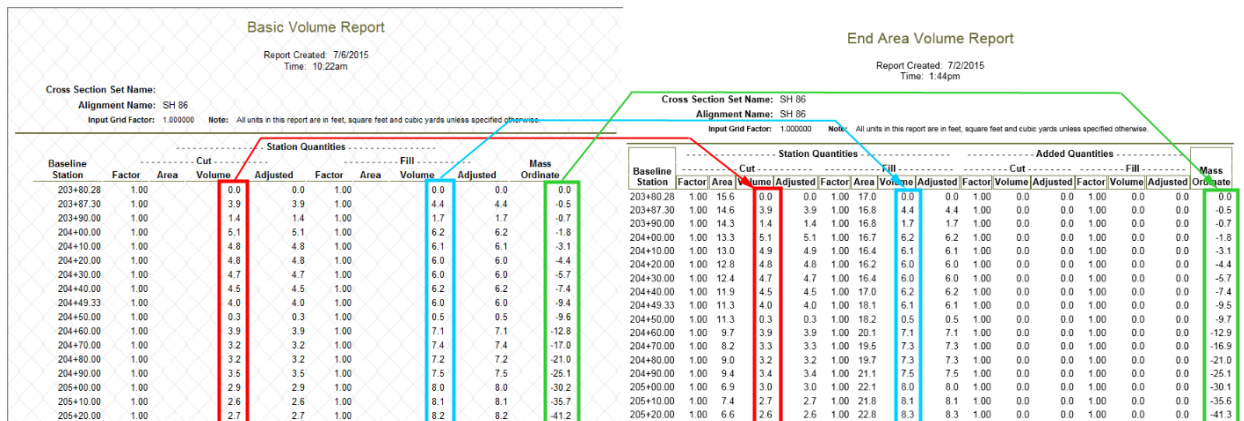
9. If needed, in the **Limits** area, toggle on **Station** and key in the **Start** and **Stop** stations. If station limits are not needed, toggle off **Station**.
10. Verify that the **Volume Factors** are both set to **1.00**.
11. Left click **Apply** to generate the report. This displays the **Bentley Civil Report Browser**.



12. In the **Bentley Civil Report Browser** select the BasicVolume.xml as the style sheet.



The illustration below shows the **Triangle Volume by Station** report on the left and the **End Area Volume** report on the right. By comparing the indicated columns station by station, the location of the discrepancy can be located.



Once the location of the issue has been determined, review the information in the plan view, cross sections, Roadway Designer, and in 3D to determine the cause of the problem.

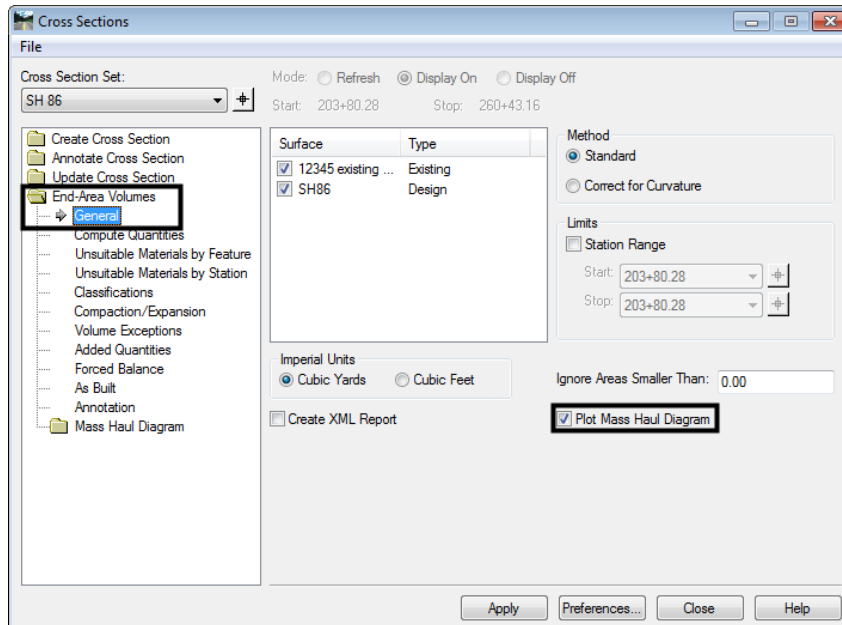
Should the two volumes be within the tolerances, then a new set of cross sections containing the surfacing components can be created for the plan set.

e. Using Mass-Haul Diagrams

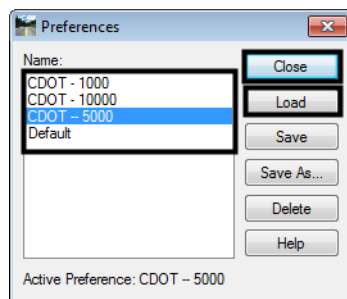
A mass haul diagram is a graphical representation of the amount of earthwork contained within a project. It can also be used to maximize the use of onsite material and reduce trucking costs.

vi. **Creating A Mass Haul Diagram** - A mass-haul diagram looks like a profile but the “ground line” represents the amount of earthwork. It is, in fact, using the Mass Ordinate for the data line. Set up the End Area Volumes dialog box as desired. To display a Mass Haul diagram:

1. Select **End-Area Volumes** from the dialog box explorer.
2. Toggle on **Plot Mass Haul Diagram**.



3. Select **Mass Haul Diagram** from the dialog box explorer.
4. Left click the **Preferences** button.
5. Select the desired preference then left click **Load** and **Close**.

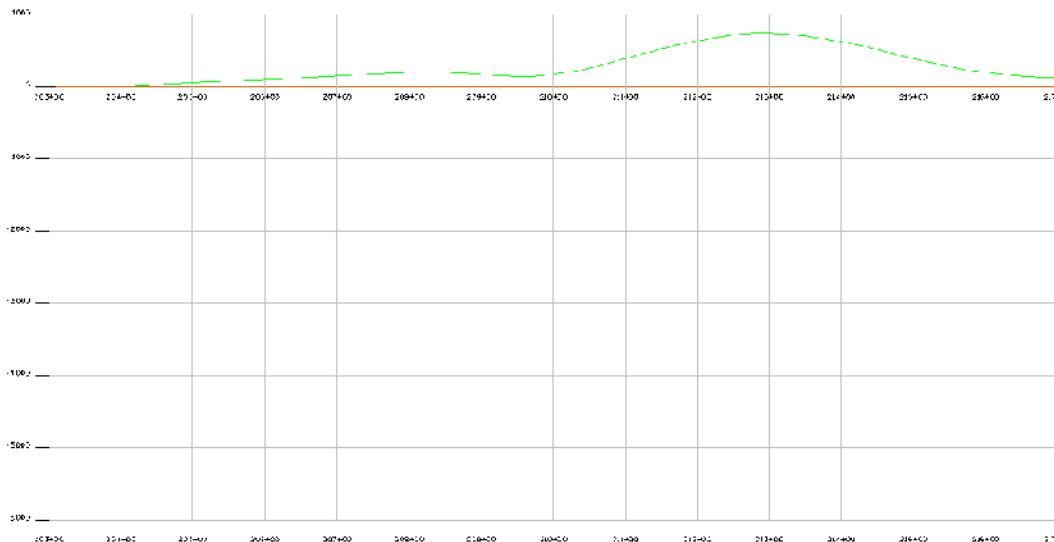


The mass-haul diagram is generated when the end-area volumes are calculated.

6. Left click the **Apply** button.
7. After the end-area volumes are calculated, you are prompted to identify the location for the mass haul diagram.

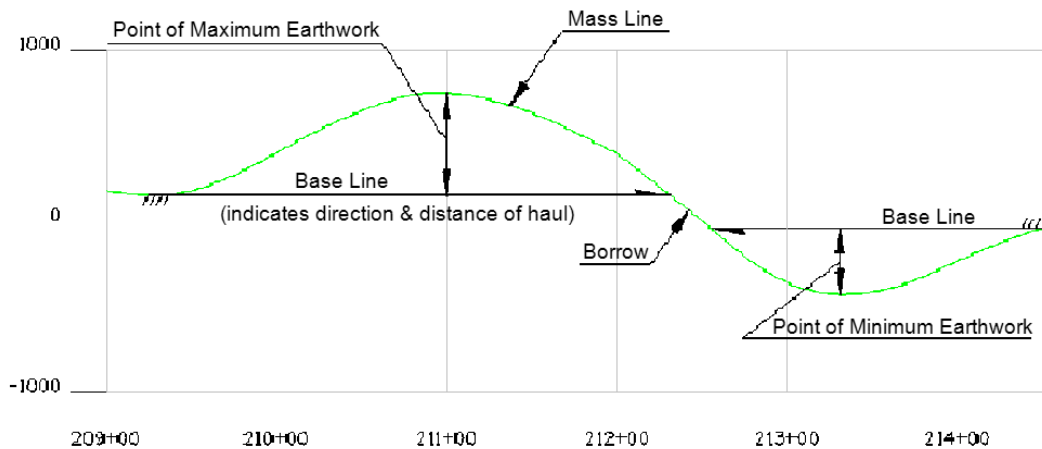
> Identify point for Mass Haul Diagram/Reject

8. Left click to identify the location of the lower left corner of the diagram. Below is an example of a mass haul diagram.



- vii. **Reading and Using a Mass Haul Diagram** - A mass haul diagram illustrates the accumulated algebraic sum of the cubic yards of earthwork on a project. These diagrams are used as an aid in balancing earthwork, computing haul distances, and calculating quantities.

The mass haul diagram is laid out with Stations running horizontally and cubic yards of earthwork running vertically. Items of interest in the diagram are:



- **Mass Line** - This is the data line of the mass haul diagram. It is a graphic representation of the Mass Ordinate that is displayed on cross sections and in the end area volume report.
- **Excavation** - This is shown by a rise in the data line when read going up station.
- **Embankment** - This is shown by a drop in the data line when read going up station.

- **Point of Maximum Earthwork** - This is where the volumes change from a net excavation to a net embankment.
- **Point of Minimum Earthwork** - This is where the volumes change from a net embankment to a net excavation.
- **Base Line** - This indicates the limits of an area of balanced earthwork (where excavation and embankment have equal values). The arrow indicates the direction of haul.
- **Borrow (or Waste)** - Borrow indicates an area where additional material will have to be brought in from off-site. Waste indicates an area where excess material must be disposed of.

It is up to the designer to indicate the Base Lines, Point of Maximum Earthwork, Point of Minimum Earthwork, and areas of Borrow or Waste on the mass haul diagram. Other items that can be added to the diagram are haul volumes for each base line, volumes for areas of borrow and waste, and sheet estimate volumes.