This document explains the procedures for creating an exterior boundary, merging surfaces, and copying features from one surface to another.

An exterior boundary eliminates inaccurate triangles that can occur in concave areas within the data.

The **Merge Surfaces** command can be used to create a single surface from two or more "existing" surfaces, update the "existing" surface with additional data, or to make an "as constructed" surface for the project by combining a proposed surface with an existing surface.

The **Copy Portion of Surface** command copies features (or portions of features) from one surface and places them in another surface. This can be used to create a new surface from elements of one or more other surfaces or to update a surface with data from another surface.

These tools can be used singularly or in conjunction with each other to achieve the desired results.

Creating an Exterior Boundary

An Exterior Boundary is a closed shape DTM feature that defines the area where triangulation can occur. InRoads will triangulate the surface (without an exterior boundary) across concave areas creating inaccurate triangles that could adversely affect proposed surface models. An exterior boundary will prevent the creation of false triangles outside of the actual data.

An exterior boundary should be created for a surface that does not currently have a boundary or for a surface that has been modified and now has usable data outside the current boundary.

Creating an Exterior Boundary for a Surface Without One

It may occur that a surface does not include an exterior boundary. If this is the case, an exterior boundary should be created and added to the surface. Adding the boundary will eliminate inaccurate triangles from the surface. Below is an example of a surface with no exterior boundary. The example is representative of what can happen when a boundary is omitted and a maximum triangle length is not defined. In the event of a missing exterior boundary, the software will calculate the inaccurate triangles shown in bold red below.
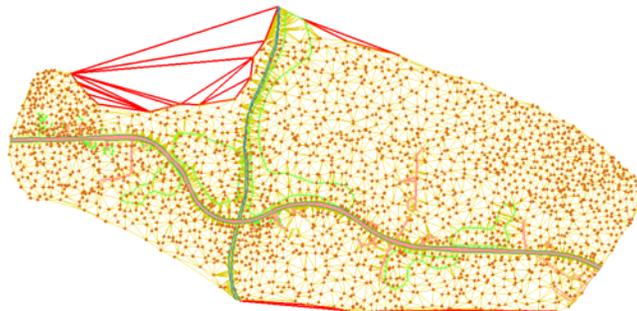

To create an exterior boundary for this surface three steps are required. One, the erroneous triangles are removed, two, the perimeter of the surface is displayed, and three, the MicroStation graphic representing that perimeter is then imported as an exterior boundary feature into the DTM.

Removing Inaccurate Triangles

Inaccurate triangles are usually long narrow triangles or those that span concave areas of a DTM. InRoads has two commands that can be used to reduce, then eliminate the number of inaccurate triangles, namely the Triangulate Surface and Delete Triangle commands. The Triangulate Surface command is used to set a limit on the length of a triangle edge, thereby reducing the number of inaccurate triangles. The Delete Triangle command is then used to eliminate the remainder of the inaccurate triangles. It should be noted that neither of these commands affect the data which was collected for the surface. The commands either modify the computation used to define triangles (in the case of Triangulate Surface) or delete specific triangles that have been defined (in the case of Delete Triangle).

Triangulate Surface

There is no definitive rule for setting the *Maximum Length* when triangulating a surface. If the length is set too short, triangles will not be defined in areas they should be, forming holes where good data was not used. Below is an example of a surface whose *Maximum Length* is set too short.
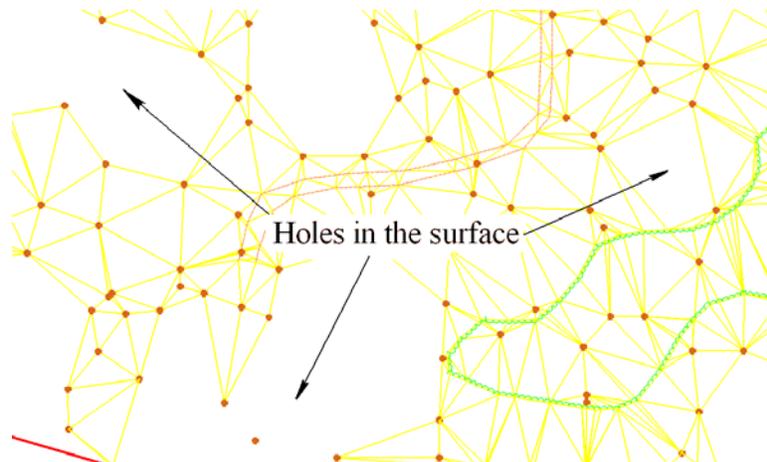
When the length is set to long, an undesirable number of inaccurate triangles will remain. A general rule of thumb is to err on the long side. It is better to have the inaccurate triangles that can later be deleted than to lose data.

To get an idea of what *Maximum Length* to use, display the surface's features and triangles. Look for the longest triangles that lie within the data area (there is no need to be exact here, the object is to get an idea for the *Maximum Length*). Measure the long side of the triangle and use that as a starting point.

1. Select Surface > Update 3D/Plan Surface Display. The Update 3-D/Plan Surface Display dialog box is displayed.

   Note: If available, reference files showing the location of survey data can be used to view the DTM features without having to display them.

2. In the Update 3D/Plan Surface Display dialog box, set the Mode to **Display On**.

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3. In the **Surfaces** list box, select the desired surface.

4. Below the Surfaces list box are a number of toggles. Toggle on **Triangles** and **Features**.

5. **<D> All** button found in the lower right corner to highlight all of the features in the **Features** list box.

6. **<D> Apply**. The dialog box will minimize while displaying the features and triangles. It will reappear when the display is complete.
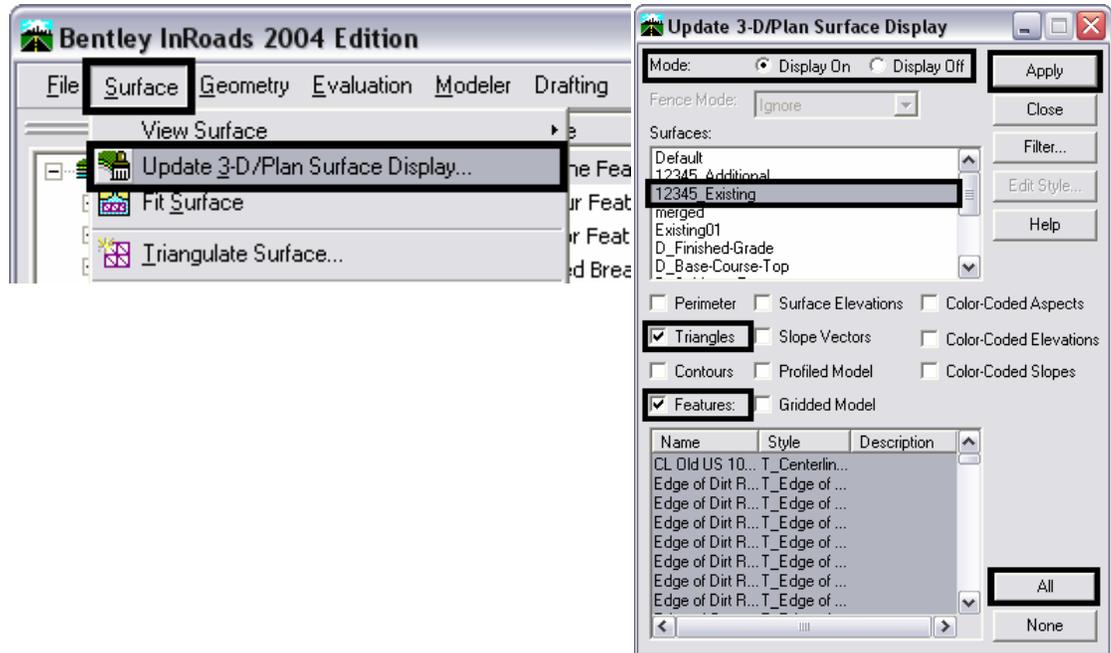

7. Scanning the triangles displayed, a large triangle within the data was located. Select the MicroStation **Measure Distance** command. In the **Measure Distance** tool settings box, set the **Distance** to ***Between Points***.

8. **<D>** at one triangle corner then the other. The distance measured will be displayed in the tool settings box.

Measure the distance between these points
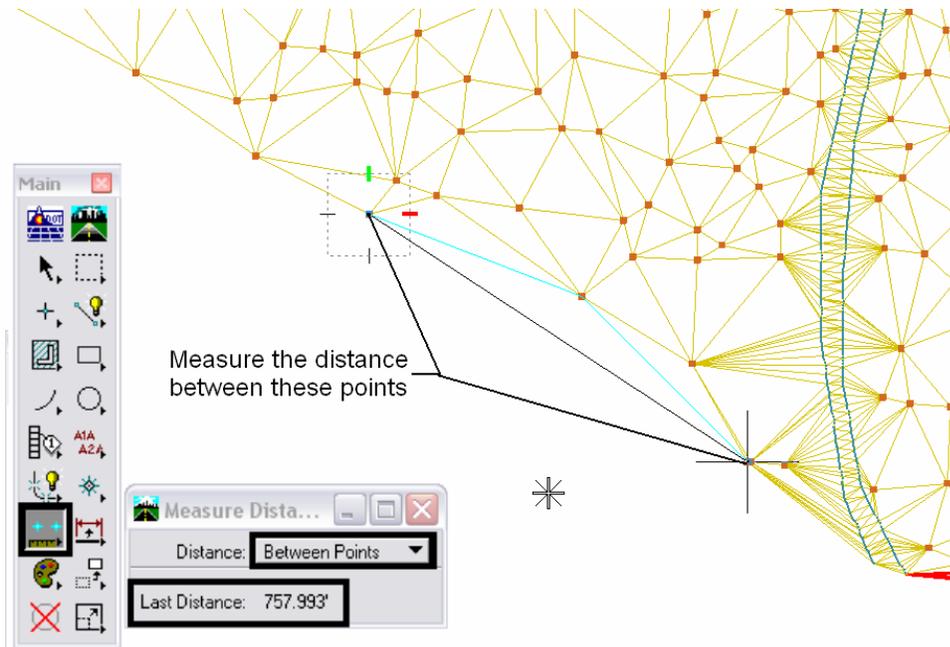
9. From InRoads select **Surface > Triangulate Surface**. This displays the **Triangulate Surface** dialog box.
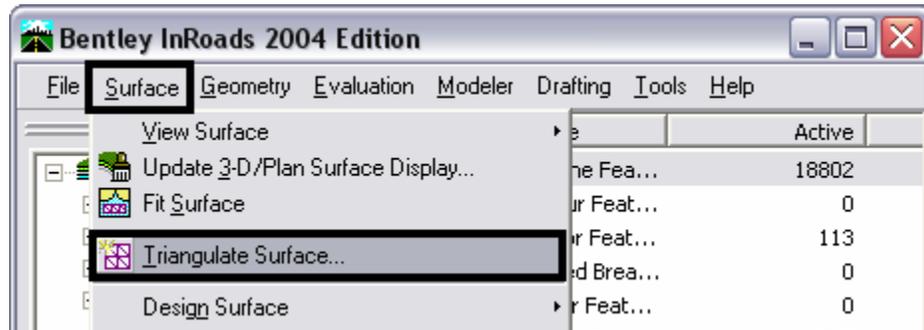

10. In the **Surface** drop-down, select the surface.

11. In the **Maximum Length** field, key in the desired length. Because this length is just an estimate, it is advisable to increase the measured length as a buffer.

12. **<D> Apply** to launch the command.
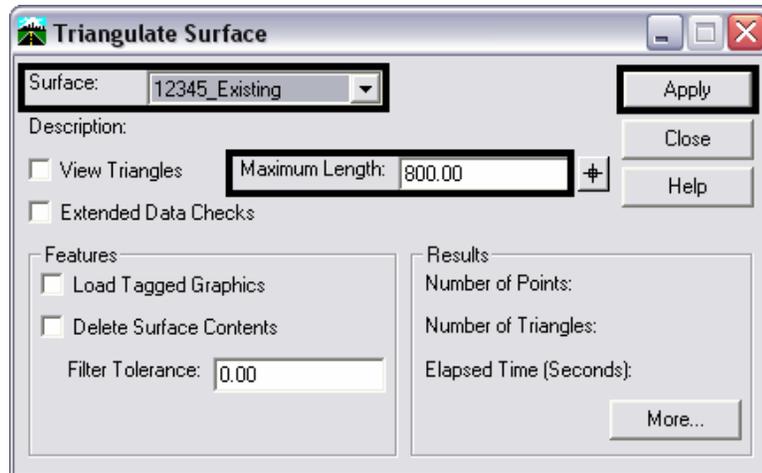
In the example above, the measured distance of the triangle edge was 757.993'. Because this may not be the biggest triangle within the data, 800' is used for the Maximum Length to insure all actual data is included.

13. Go back to the **Update 3D/Plan Surface Display** dialog box, toggle off **Features**, then **<D> Apply**. This will redisplay the triangles as computed using the *Maximum Length* set above.

14. Examine the triangles to be sure no actual data was lost. Look for features not connected by triangles. If good triangles were lost, go back to the **Triangulate Surface** dialog box, increase the *Maximum Length* and *Apply* the new settings. Repeat this process as necessary until the desired results are obtained.
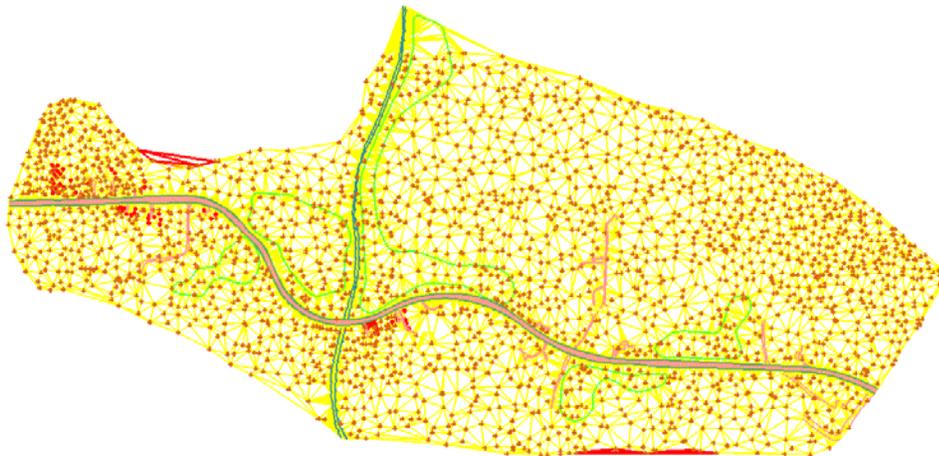

In the example above, most of the inaccurate triangles have been deleted by setting the *Maximum Length* and re-triangulating the surface. The remainder will be eliminated using the **Delete Triangle** command.
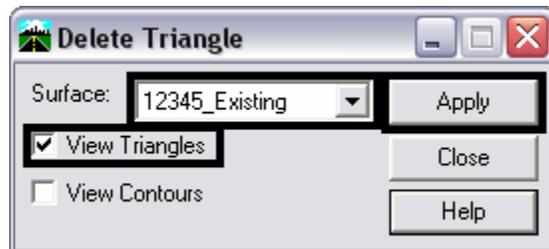
Delete Triangle

Now that the number of inaccurate triangles has been reduced to a manageable level, the rest can be removed easily with the Delete Triangle command.

15. Zoom in on the area where triangles are to be deleted.
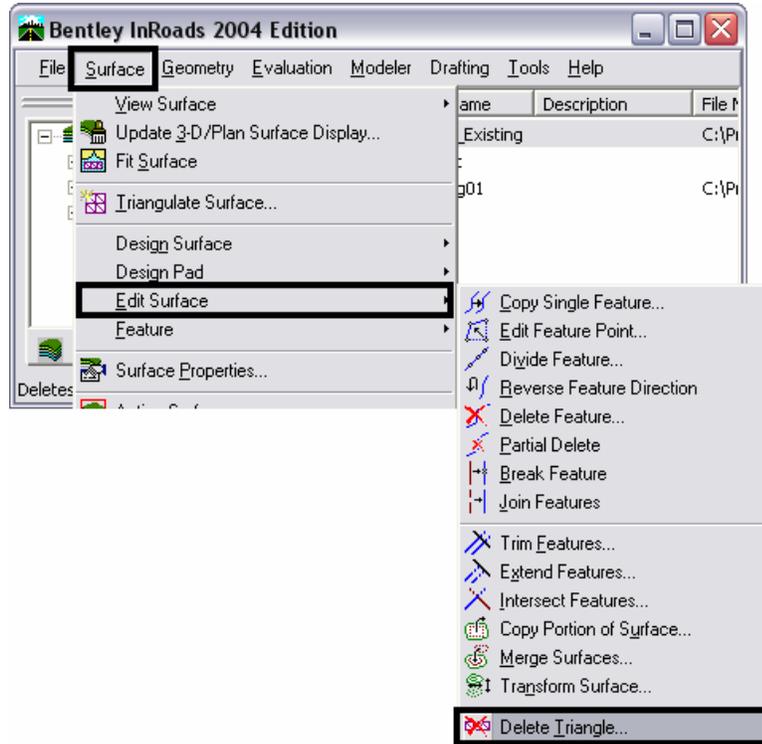
16. From InRoads, select **Surface > Edit Surface > Delete Triangle**. This displays the **Delete Triangle** dialog box.

17. In the **Delete Triangle** dialog box, use the **Surface** drop-down to select the desired surface.

18. *Toggle* on **View Triangles**. This will dynamically display the triangles to be removed. After the triangles are deleted (from memory) if the view is updated, the original triangles that were written to the CAD file will reappear. To update the MicroStation graphics, the triangles will have to be redisplayed (use the **Surface > View Surface > Triangles** command).

19. **<D> Apply**.

20. The **Delete Triangle** dialog box will minimize. **<D>** inside the first triangle to be deleted, then move the cursor through other adjacent triangles that are to be deleted. Be sure not to pass through triangles you do not want to delete. The triangles will highlight as they are passed through.
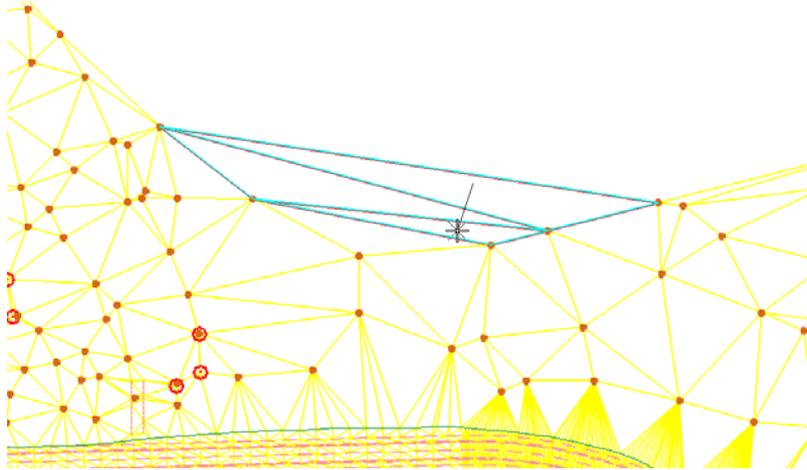
21. After the last triangle in the group is selected, **<D>** to end triangle selection. The *Accept/Reject* prompt is displayed. **<D>** to confirm deletion of the triangles, **<R>** to reject the selection.
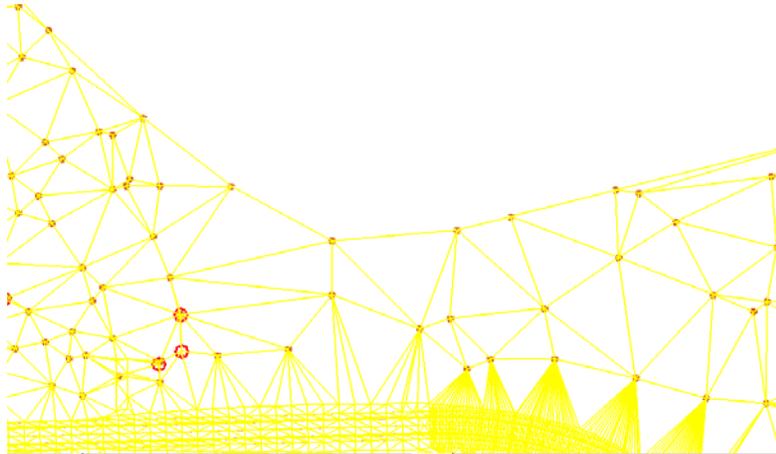
In the example above the display is temporarily updated, eliminating the deleted triangles.

22. Using the same process, delete the remaining inaccurate triangles. After all of the desired triangles are deleted, **<D>** Close to dismiss the **Delete Triangle** dialog box.

    Note: Do not re-triangulate the surface until the exterior boundary is added to the DTM. Otherwise all deleted triangles will regenerate.

23. From the InRoads dialog box, select **Surface > View Surface > Triangles** (or use the **Update 3D/Plan Surface Display)** to permanently change the updated triangle display.
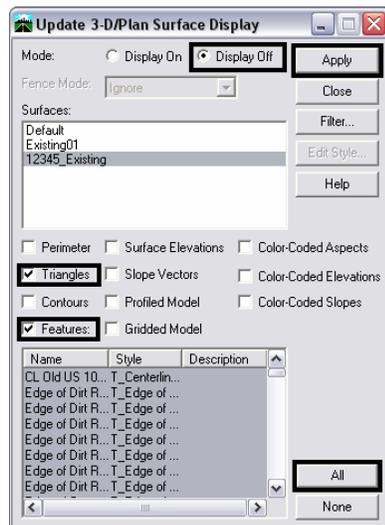
Displaying the Exterior Boundary

After the triangles have been edited, the exterior boundary can be created. To create the boundary, the perimeter of the triangulated area will be displayed and that perimeter will be imported as the exterior boundary.

24. From the InRoads dialog box, select **Surface > Update 3D/Plan Surface Display**.

25. In the **Update 3D/Plan Surface Display** dialog box, Set the **Mode** to **Display On**.

26. In the **Surfaces** list box, select the desired surface.

27. Toggle on **Perimeter**. All other toggles should be off. **<D> Apply** to display the perimeter.
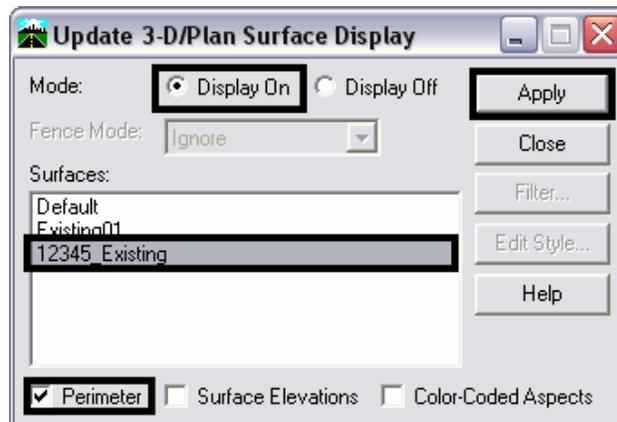

28. At this point the display of the triangles and features is not needed. In the **Update 3D/Plan Surface Display** dialog box, Set the **Mode** to **Display Off**.

29. Toggle on **Triangles** and **Features**. All other toggles should be off.

30. **<D> All** to highlight all of the features in the list box.

31. **<D> Apply** to remove the triangles and features from the graphics display.

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To complete the exterior boundary process, the perimeter must now be imported as a feature into the surface.

32. From InRoads, select **File** > **Import** > **Surface**. The **Import Surface** dialog box will be displayed.
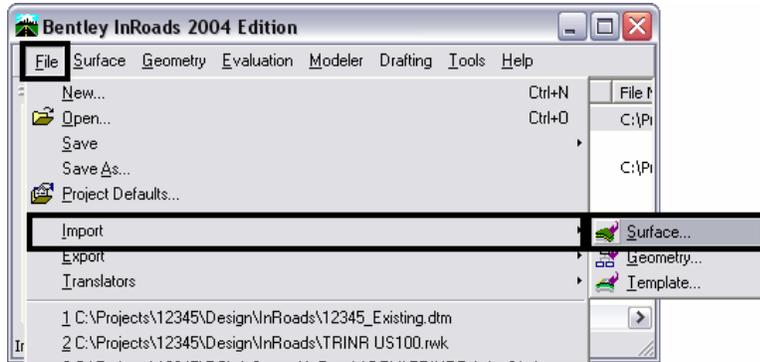
33. Select the *From Graphics* tab. Select the desired surface from the **Surface** drop-down.

34. Select *Single Element* from the **Load From** drop-down.

35. In the *Features* area of the dialog box, key in *DTM_Exterior* in the **Seed Name** field.

36. From the **Feature Style** drop-down list, select *DTM_Exterior*.

37. From the **Point Type** drop-down list, select *Exterior*.

38. After the specified changes are made, <D> **Apply**.
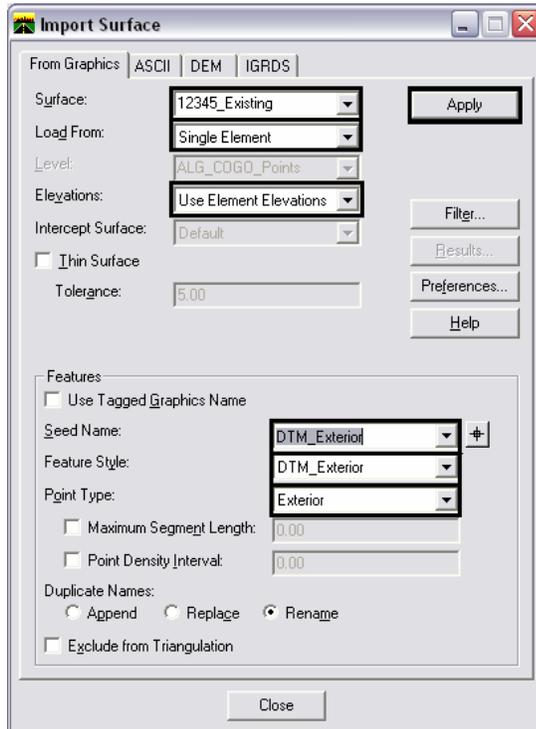
39. **<D>** on the boundary shape. The shape will highlight. <D> again in the blank area of the screen to accept the element and add it to the surface. Dismiss the Import Surface dialog.

40. To *verify* that the data was imported, select **Surface > Feature > Feature Properties**. This displays the **Feature Properties** dialog box.

41. *Verify* that the desired surface is selected in the **Surface** drop-down.

42. *Verify* that **DTM_Exterior** appears in the **Feature** list box. Also verify that the **Feature Type** is set to *Exterior* in the *Triangulation* area.
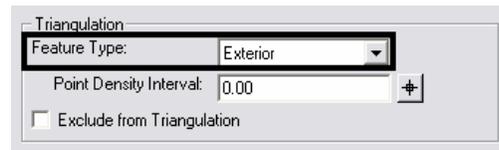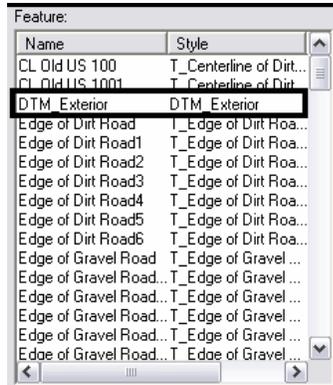

To complete the process, the surface must be re-triangulated.

Merging Surfaces

The InRoads **Merge Surfaces** command is used to create a single surface from two surfaces. The surfaces being merged must be adjacent or overlapping. The merging of surfaces that are not adjacent or overlapping would result in inaccurate triangles between the areas of data.

In the examples below, the original surface is being extended by using information contained in an additional surface. The solid line represents the perimeter of the "Original" surface. The dashed line represents the perimeter of the additional surface to be merged, identified as the "Design" surface in the Merge Surfaces dialog box.
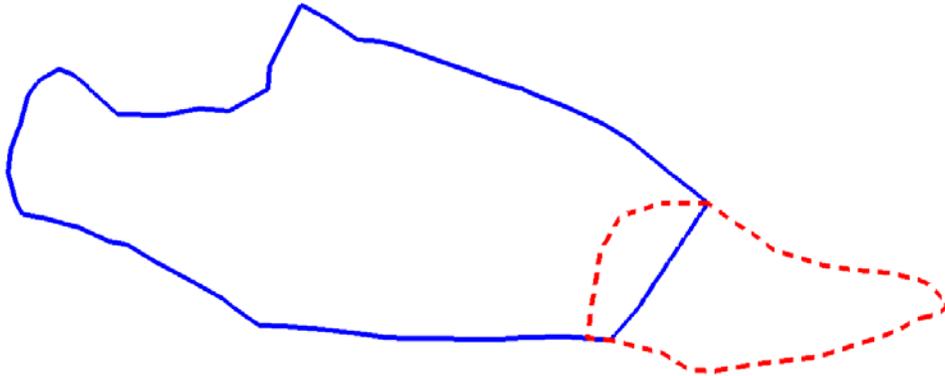
Prerequisites

Before two surfaces can be merged, they must both be opened in InRoads.

1. From InRoads main menu, select **Surface > Edit Surface > Merge Surfaces**. This will result in the display the **Merge Surfaces** dialog box.
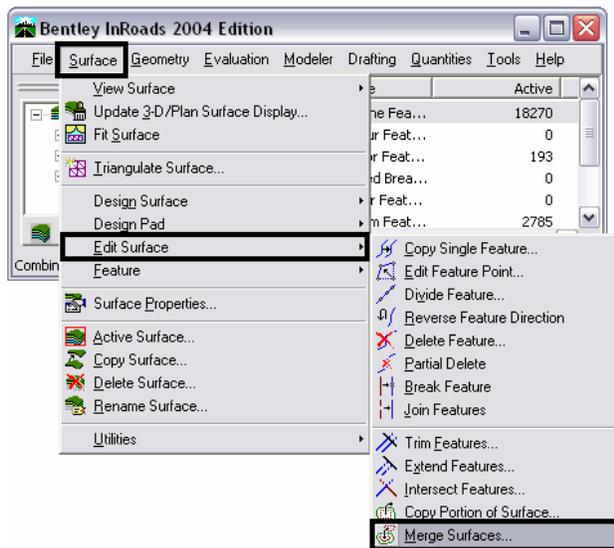

2. This command operates with three surfaces; the original surface, the design surface, and the destination surface which will be created upon execution of the command.

Original Surface- This is the surface whose features can be deleted or partially deleted in areas that overlap with the merging (Design) surface. Typically, this will be the Existing surface received from ROW/Survey, however it can be any surface. If the original and design surfaces overlap, the common area between the two will be occupied by data from the Design Surface and data from the Original Surface may be removed, depending on the toggle settings described below.

Design Surface- This surface usually contains additional existing surface data or the Finished Grade surface generated from Roadway Modeler. *Design Surface* data can either replace or supplement the *Original Surface* data in areas where they overlap depending on the toggled setting Retain All Original Surface Points. In the illustration below, the shaded area shows the overlap between the original and design surfaces. The data from the *Original Surface* in this area will be deleted and only the *Design Surface* data will remain unless Retain All Original Surface Points is toggled on.

Note: The *Original Surface* and the *Design Surface* remain intact. The Retain All Original Surface Points setting only affects the creation of the *Destination Surface*.
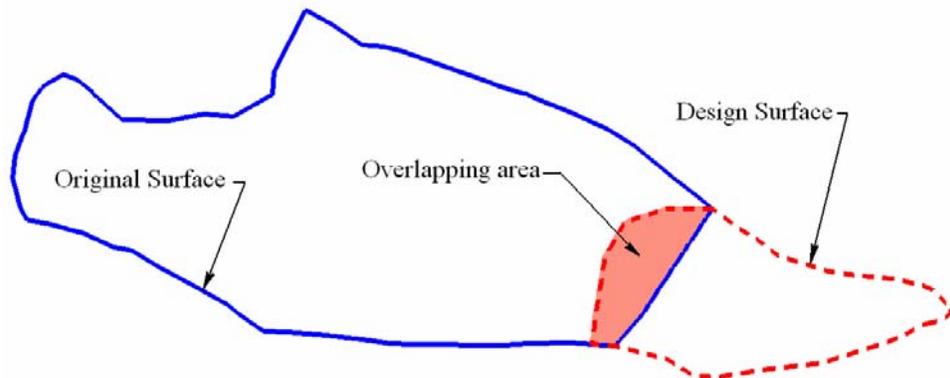
Destination Surface- This surface stores the results of the Merge command.

Use the pull downs in the Merge Surfaces dialog box to select the desired surface for Original, Design, and Destination. If a destination surface has not previously been created or loaded, it can be created "on the fly" by typing the desired name in the Destination field.
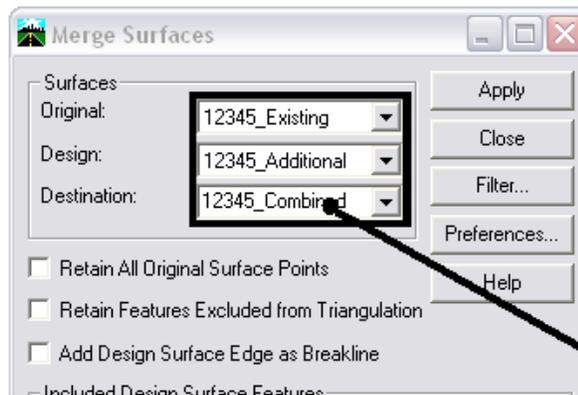
A Destination surface name can be keyed in here to create the surface "on the fly".

3. The next area of the Merge Surfaces dialog box contains three toggles: Retain All Original Surface Points, Retain Features Excluded from Triangulation, and Add Design Surface Edge as Breakline.

    Retain All Original Surface Points- When checked on, all of the original surface's features will be stored in the destination surface. When checked off, the original surface features that cross into the design surface's perimeter will be clipped at the perimeter leaving only the design surface's features in that area. By default the option is checked off.

    Retain Features Excluded From Triangulation- When checked on, features excluded from triangulation from the original surface, like underground utilities, will be stored in the destination surface, regardless of their relationship to the design surface. When checked off, features excluded from triangulation will be treated as any other feature in the original surface. Un-triangulated features from the design surface by default are <u>always</u> included in the destination surface.

    Add Design Surface Edge as Breakline- When checked on, the perimeter of the design surface is added to the destination surface as a breakline. This will ensure that the design surface maintains its original triangle structure. When off, the perimeter is not added and the design surface's triangle structure can be modified by the original surface data. This option should be turned *on* when creating an "as constructed" surface. It should be turned *off* when extending or modifying the existing surface.

    Turn on or off the toggles as desired.
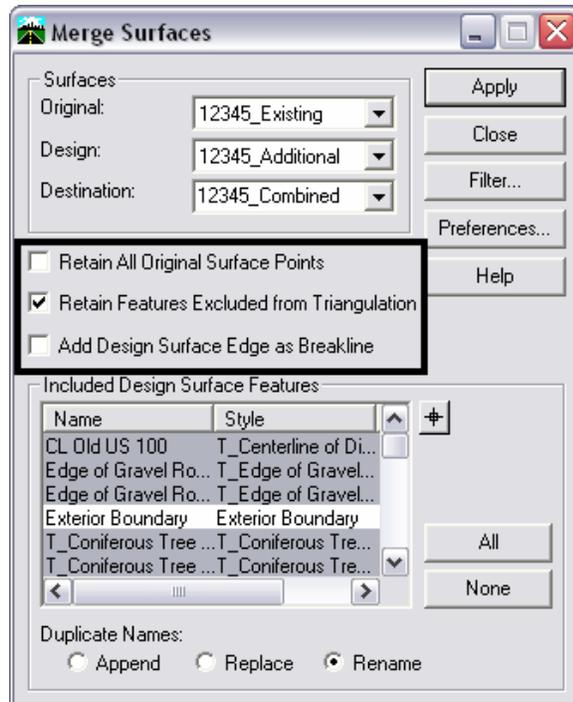
4. The **Merge Surfaces** dialog box contains an area for including and excluding design features from the destination surface. In the *Included Design Surface Features* area, highlighted features will be added to the destination surface and un-highlighted features will not. By default all features are highlighted.
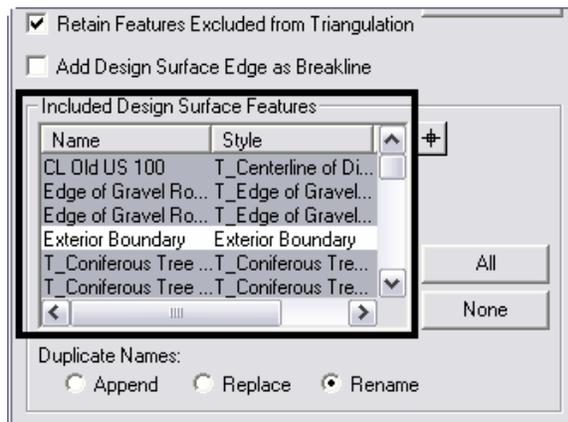
Note: Because this is an example of extending a surface, the Exterior Boundary of the design surface is not highlighted. When creating an "as constructed" surface leave all the features on.

5. Options for resolving feature naming conflicts are located at the bottom of the settings box under **Duplicate Names**. The options are:

Append- This adds the points from the new feature to those of the existing feature, making one feature out of the two. The combined feature will have a discontinuity (a gap) from the last point of the existing feature to the first point of the new feature.

Replace- The existing feature will be deleted and replaced by the new feature with this option.

Rename- The new feature will be renamed by appending a '1' to the end of the name.

By default the **Rename** option is selected.
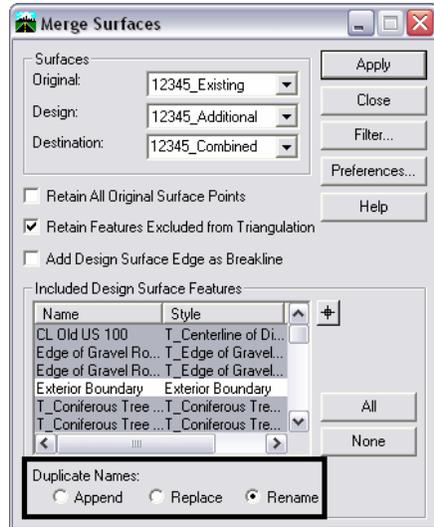
6. Once the desired settings are made, **<D> Apply** to execute the command. If the destination surface did not exist when the command was launched, it will be created now. After the command has been run, the destination surface will be added to the file list in the main InRoads interface. The **Merge Surfaces** dialog box can now be dismissed.
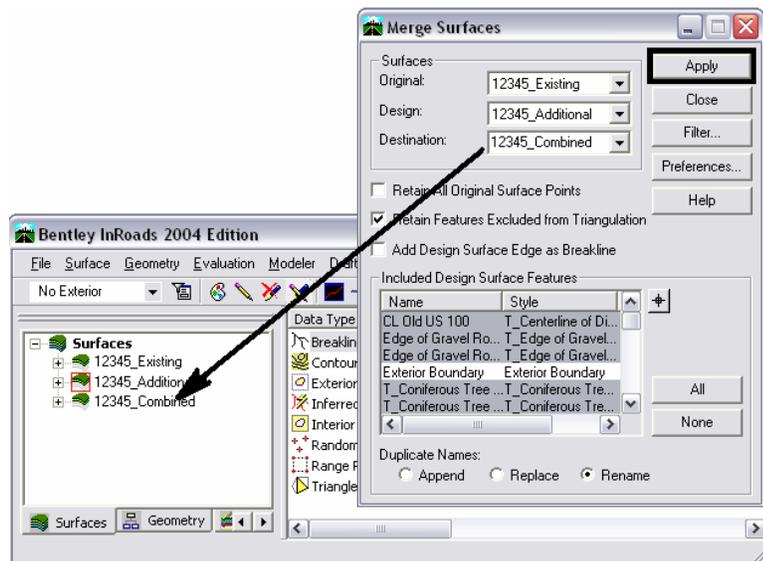
If the design surface was at least partially outside the area of the original surface (as is the case in this example), a random feature will be created in the combined surface using the original surface's exterior boundary name. This feature should be deleted prior to creating the new exterior boundary. To determine if the random exterior boundary feature was created, look at the **Feature** list in the **Feature Properties** dialog box (**Surface > Feature > Feature Properties**).
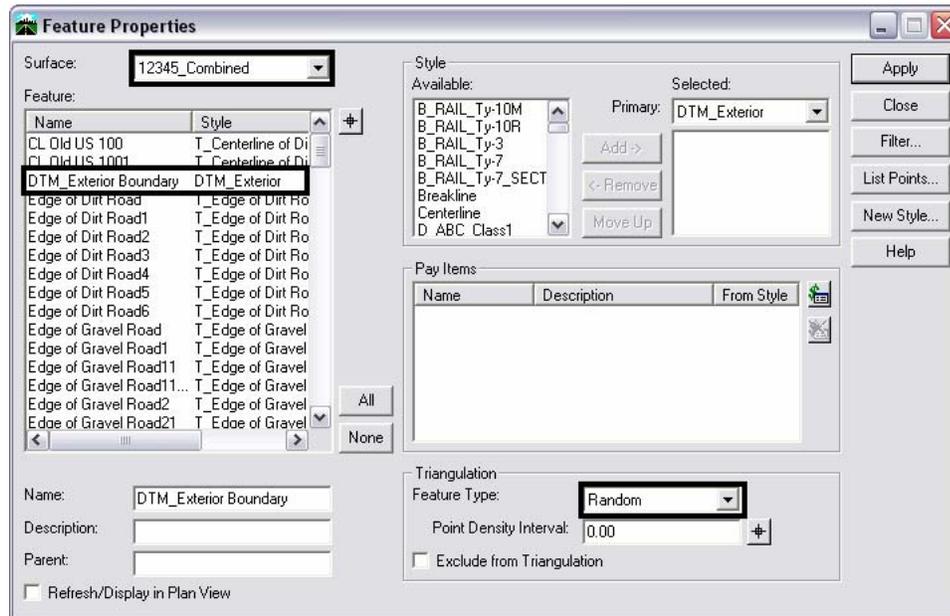

If the design surface is entirely within the area of the original surface, the original surface's exterior boundary should be retained.

7. To delete the random feature that uses the original surface's exterior boundary name, select the InRoads command **Surface > Edit Surface > Delete Feature**.
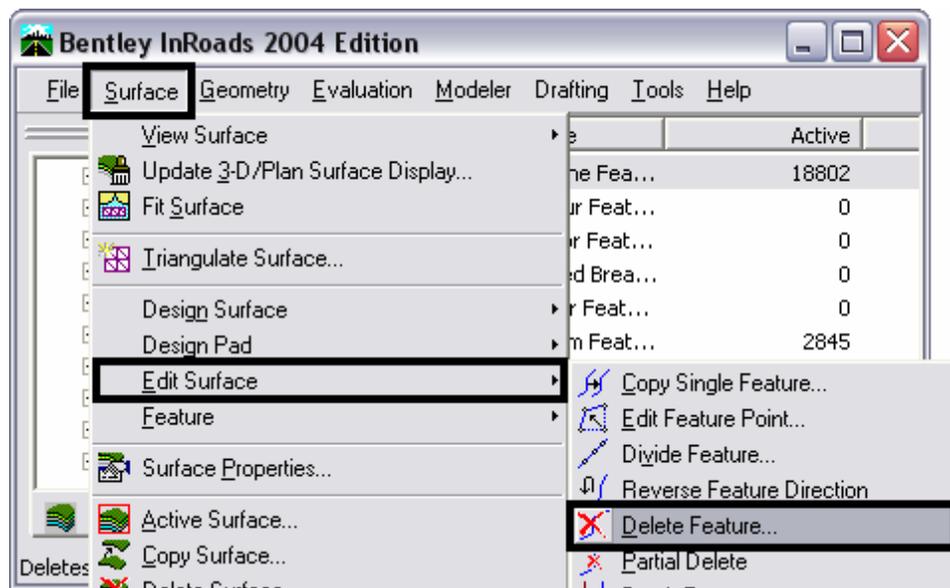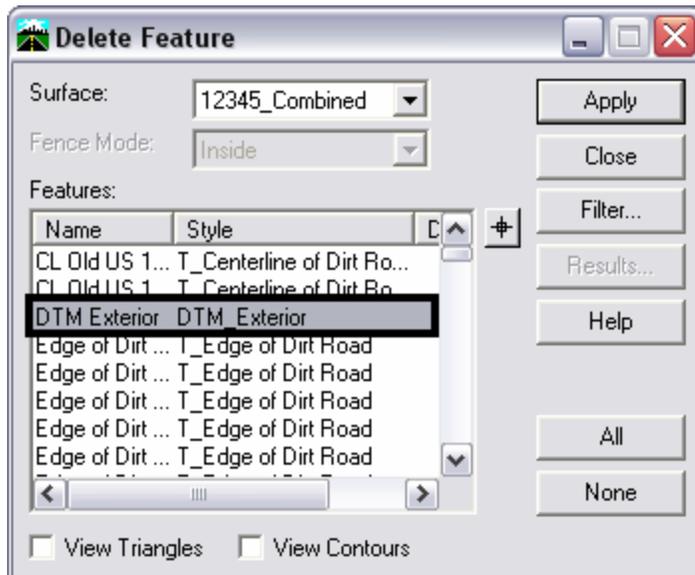
8. The **Delete Feature** dialog box will be displayed. Use the **Surface** drop-down to select the merged surface.
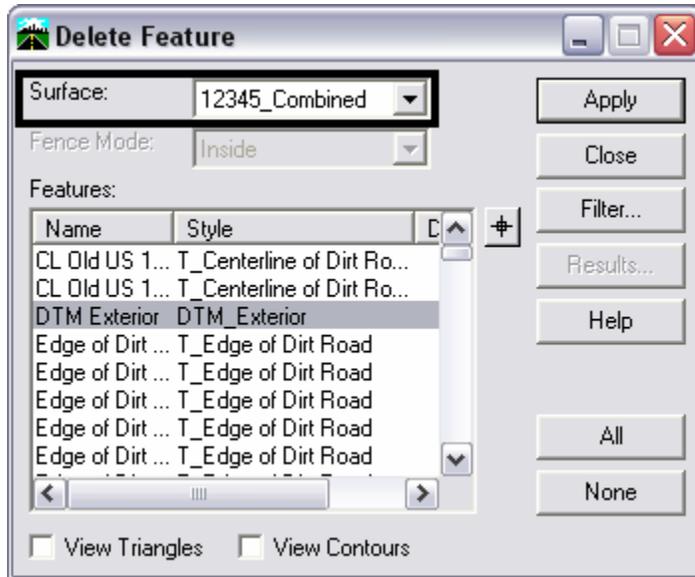

> **Note:** When on, the View Triangles and View Contours will display the triangles and/or contours (as temporary graphics) in the area of the deleted feature. Since deleting this feature will not affect the triangulation of the surface in its current state, these toggles should be left off.

9. From the **Features** list, highlight the exterior boundary feature (this will usually be named **_DTM Exterior_**).

10. **<D> Apply**. A *"Delete selected feature(s)?"* warning message will display. **<D> OK** to complete the deletion. The **Delete Feature** dialog box can be dismissed. It is advisable not to re-triangulate the surface until a new exterior boundary is added.
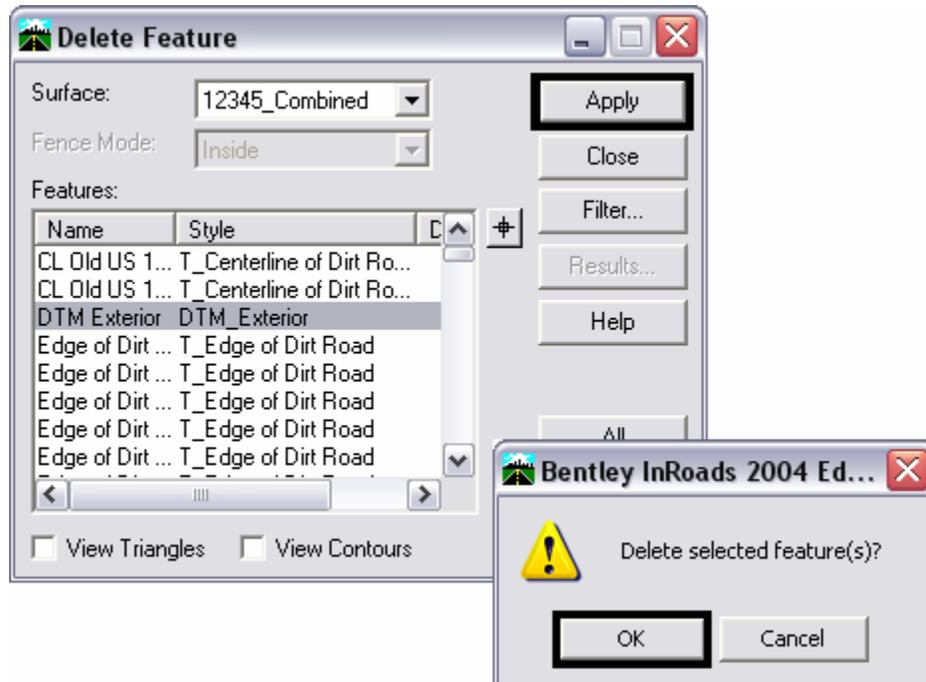
The combined surface is now ready for a new exterior boundary.

## Creating an Exterior Boundary for the Merged Surface

To create the exterior boundary for the merged surface, the exterior boundaries of the source surfaces will be used. This will only be required if the design surface used in the Merge Surfaces operation lays at least partly outside the area of the Original surface. If the design surface is entirely within the area of the original surface, the original surface's exterior boundary will be retained and this process can be omitted.

1. Select **Surface >View Surface > Features** from the InRoads dialog box.
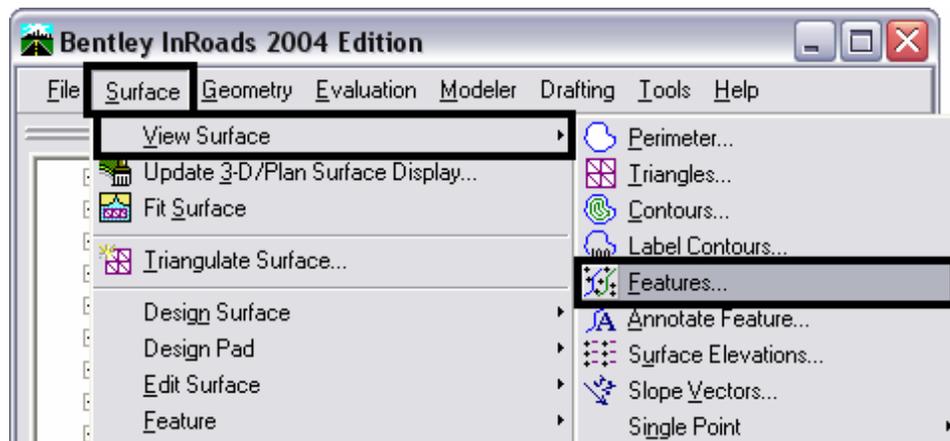
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2. This will result in the display of the **View Features** dialog box. From the **Surface** drop-down, select the *Design* surface, ***12345_Additional*** (see *Merging Surfaces* Step 2).
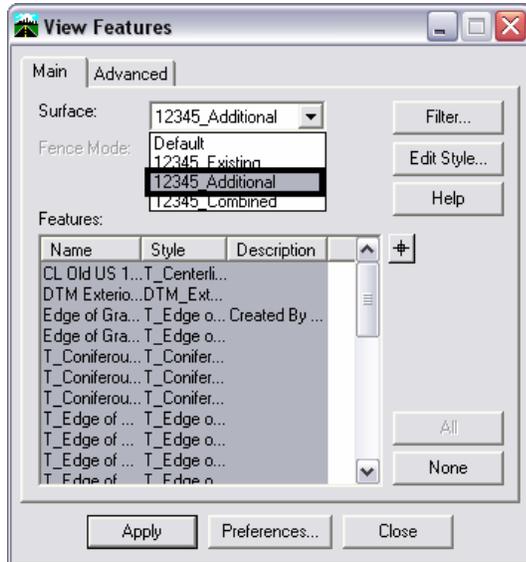

3. By default, all of the features are highlighted. **<D> None** to un-highlight all of the listed features. Next, highlight only the exterior boundary feature. **<D> Apply** to display the exterior boundary feature. Do not dismiss the **View Features** dialog box yet, as it will be used again.
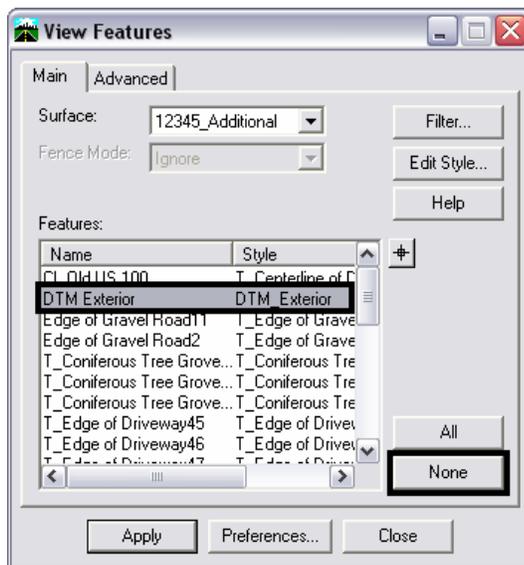

4. Place a fence using the exterior boundary of the design surface as the fence shape. By placing the fence, the exterior boundary of the original surface can be displayed clipping out the overlapping area so that less editing is required to finish the new exterior boundary.

5. Select the **Place Fence** command from the MicroStation Main toolbar. Set the **Fence Type** to *Element* and **Fence Mode** to *Inside.*
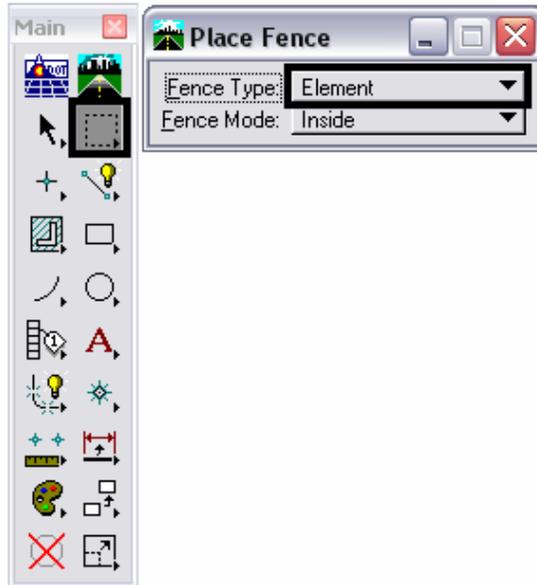

6. Select the design surface's exterior boundary displayed in Step 3 above. Left click again, anywhere in the view to accept the element. This places a fence on the element.
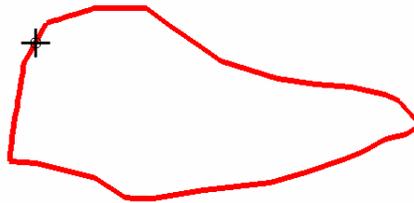

7. Go back to the **View Features** dialog box. Set the **Surface** to *12345_Existing* (the *Original* surface from *Merging Surfaces* step 2).

8. Using the **Fence Mode** drop-down, select the *Outside* option. This will only display the part of the original exterior boundary that is outside of the design exterior boundary.

9. **<D> None** to un-highlight all features in the **Features** listbox, then highlight the *DTM Exterior* boundary feature only. **<D> Apply** to display this feature. The **View Features** dialog box can now be dismissed.

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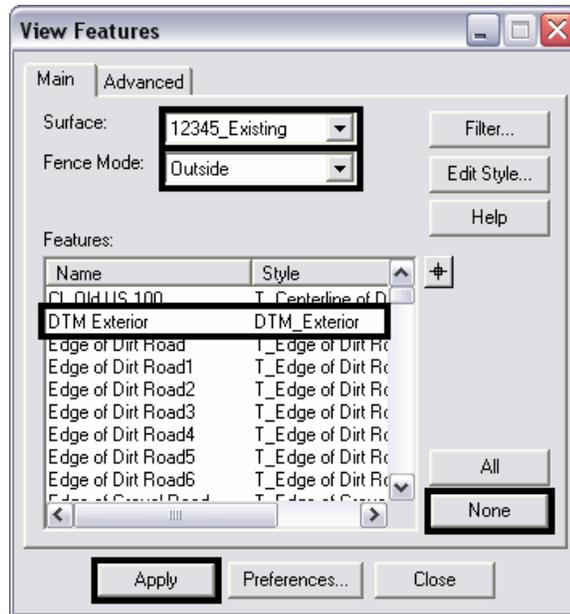
10. *Dismiss* the fence by selecting the **Place Fence** command again. The results of this operation will look similar to the example below:
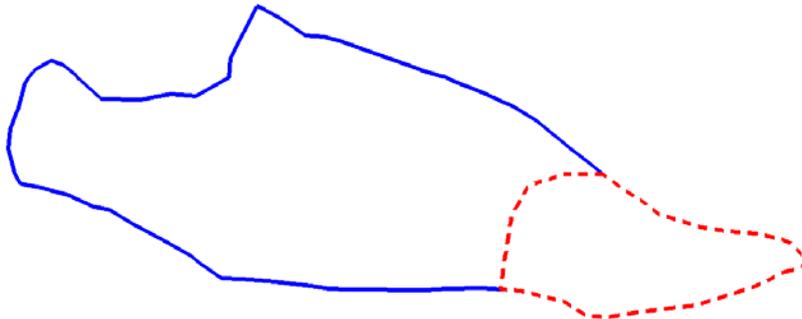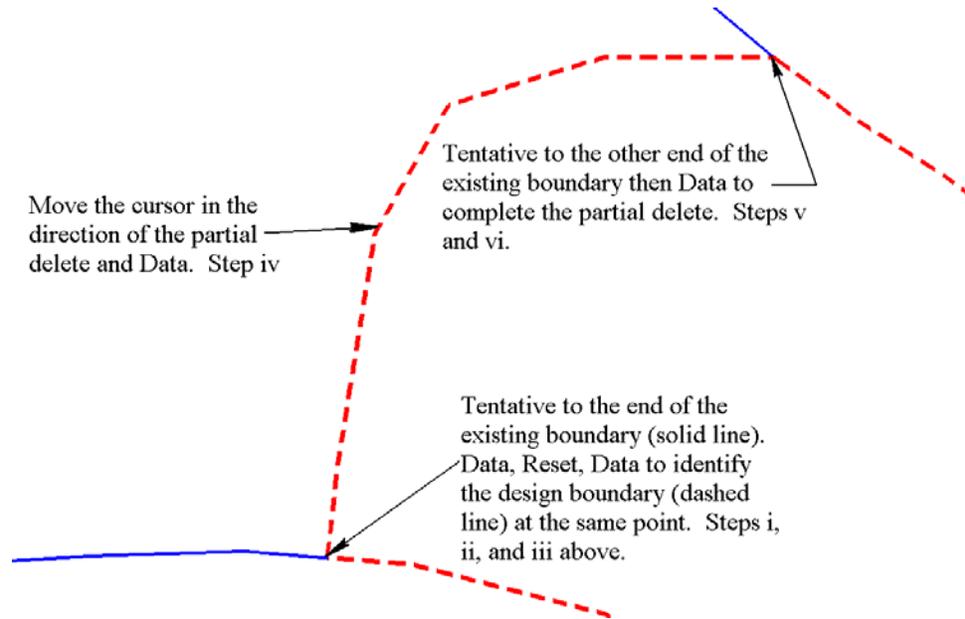

11. In order to get the element ends to match properly, use the following procedure, starting with selecting the **Partial Delete** command from the MicroStation Main toolbar:


    i.   Move the cursor near the end of the original exterior boundary (solid line) and **<T>** (middle mouse click).

    ii.   **<D>** (left mouse click) to accept the snap. The original boundary will be highlighted.

    iii.   Next, **<R>** (right mouse click). This will un-highlight the original boundary and highlight the design boundary (dashed line) where the two meet.

    iv.   To identify the direction of the partial delete, move the cursor along the part of the element to be deleted and **<D>**.

    v.   **<T>** to the other end of the original exterior boundary.

vi.   **<D>** to accept the snap and complete the partial delete.

Move the cursor in the direction of the partial delete and Data. Step iv

Tentative to the other end of the existing boundary then Data to complete the partial delete. Steps v and vi.

Tentative to the end of the existing boundary (solid line). Data, Reset, Data to identify the design boundary (dashed line) at the same point. Steps i, ii, and iii above.
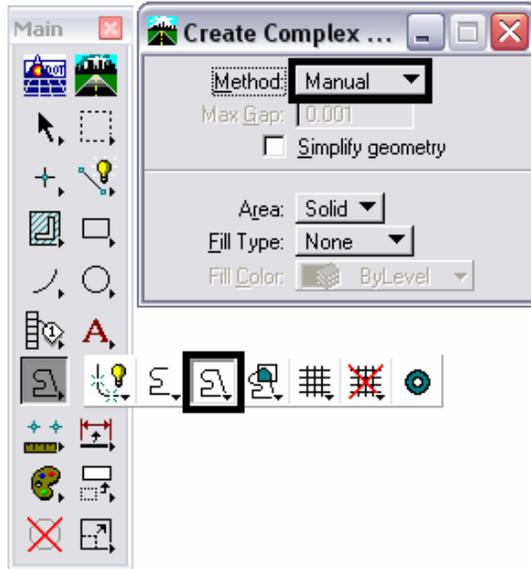
The result will be two elements that represent the desired extent of the exterior boundary of the merged surfaces.
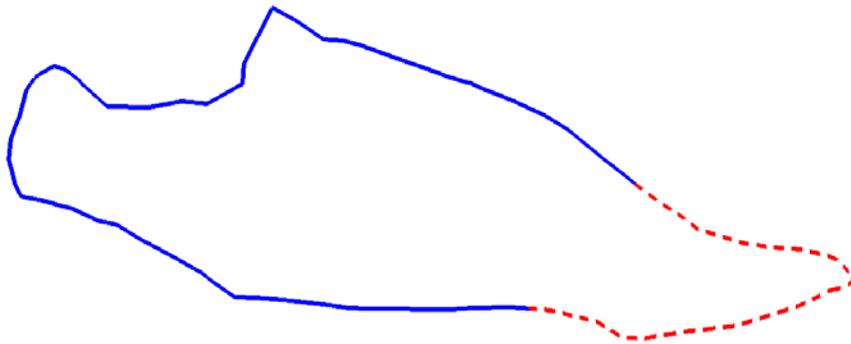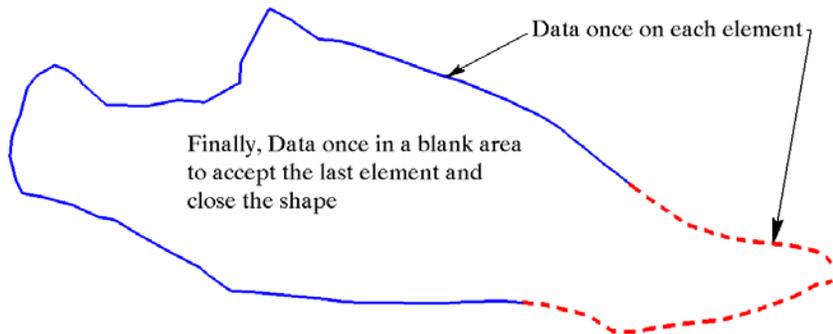
Next, a closed shape must be made of the two elements. Select the **Create Complex Shape** command from the MicroStation Main toolbar. From the **Method** drop-down list select ***Manual***.

12. **<D>** on element one (solid line) then **<D>** on element two (dashed line). **<D>** once more in a blank area on the screen to finalize the command.


The shape is now ready to be incorporated into the combined surface as an exterior boundary. Steps 13 through 16 determine how and where data from the element will be stored; steps 17 through 19 determine its feature properties.

13. From InRoads, select **File > Import > Surface**. The **Import Surface** dialog box will be displayed.

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14. Select the *From Graphics* tab. Select the combined surface created with the **Merged Surfaces** command (Merge Surfaces step 2 above) from the **Surface** drop-down.

15. Select *Single Element* from the **Load From** drop-down.

16. Select *Use Element Elevations* from the **Elevation** drop-down.

17. In the *Features* area of the dialog box, key in *DTM_Exterior* in the **Seed Name** field. This will not appear in the drop down list because the original exterior boundary features were deleted from the surface in steps 7 through 10 above.

18. In the **Feature Style** drop-down, select *DTM_Exterior*

19. Using the **Point Type** drop-down, select *Exterior*.

20. After the above settings are made <D> **Apply**.
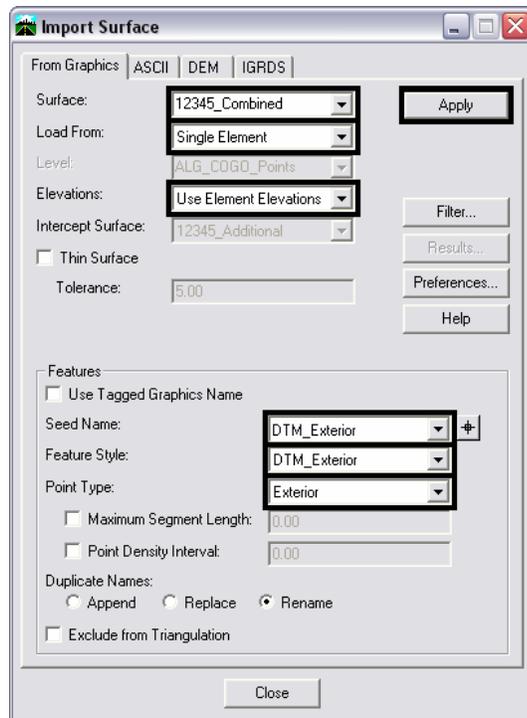
21. **<D>** on the complete boundary shape created earlier. The shape will highlight. **<D>** again in a blank area on the screen to accept the element and add it to the merged surface. Dismiss the **Import Surface** dialog box

22. To verify that the data was imported, select **Surface > Feature > Feature Properties.** This displays the **Feature Properties** dialog box.

23. *Verify* that the merged surface is selected from the **Surface** drop-down list.

24. *Verify* that **DTM_Exterior** appears in the **Feature** list box. Also verify that the **Feature Type** is set to *Exterior* in the *Triangulation* area.
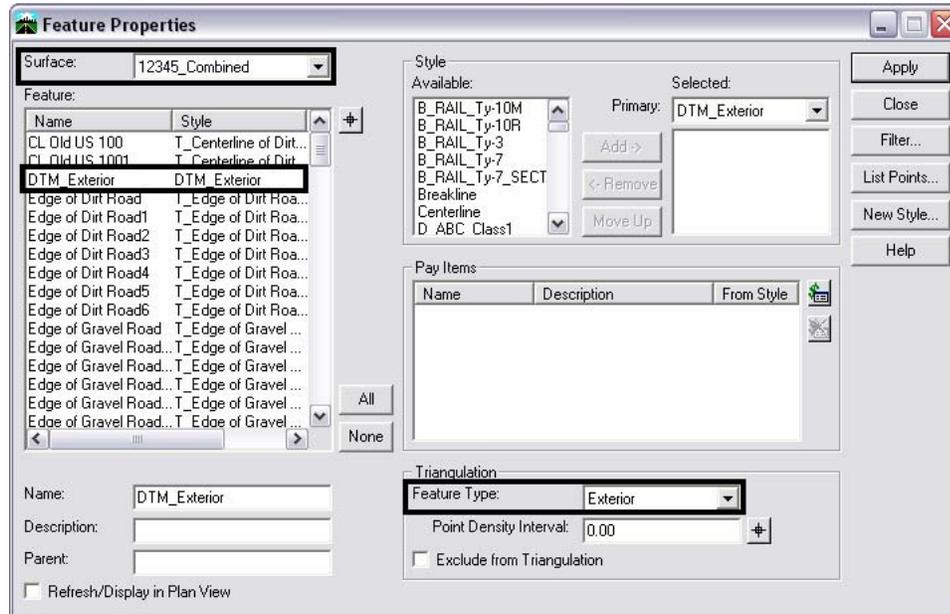
To complete the process, the surface must be re-triangulated.

25. From InRoads select **Surface > Triangulate Surface**. The **Triangulate Surface** dialog box is displayed. One could also right click on the surface name in the InRoads Explorer and select **Triangulate** from the menu.
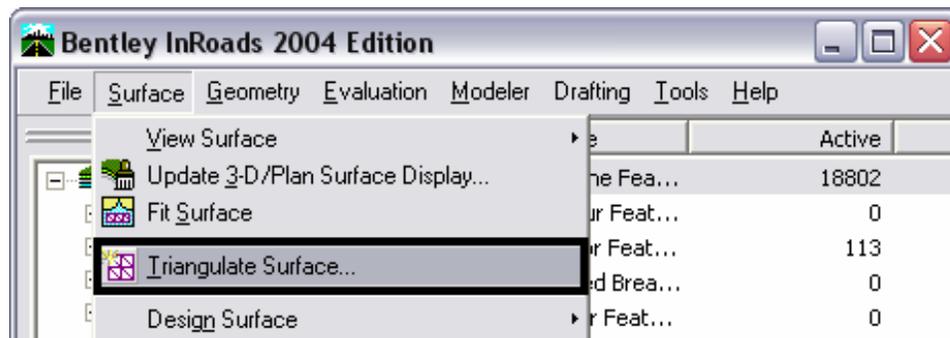
26. From the **Surface** drop-down list, select the merged surface.

27. In the **Maximum Length** field, key in the desired length. This option will automatically remove any triangles that have at least one edge longer than the specified distance. Zero indicates no restriction to length. Because the surface has an exterior boundary, 'O' should be used to ensure that all of the data is included in the triangulated surface.

28. **<D> Apply** to execute the command.
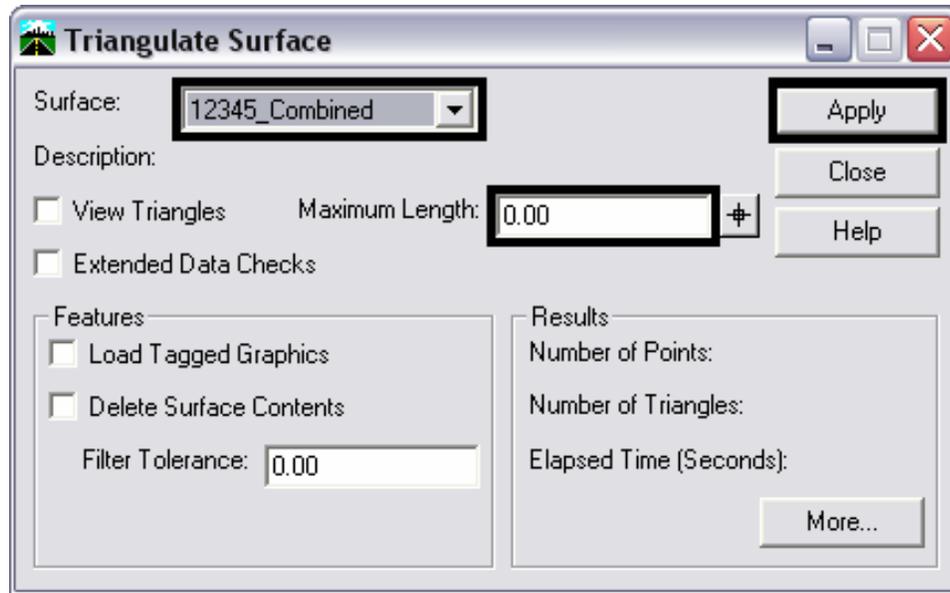
29. When the command has finished processing, surface information will be displayed in the *Results* area of the Triangulate Surface dialog box. The exterior boundary is now part of the surface and the Triangulate Surface dialog box can be dismissed.
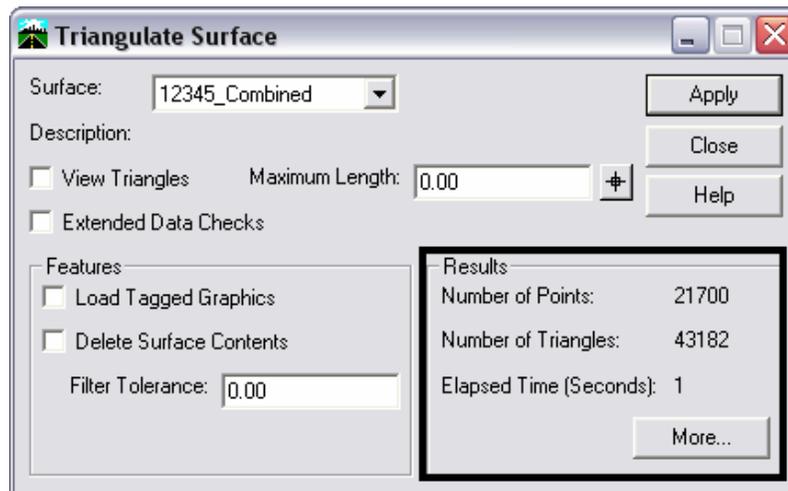
Now that the merged surface is complete, it should be saved.

30. From InRoads, select File > Save > Surface. If the surface has been saved previously, the updated data will be written to the DTM file. If the surface has not been saved before, then a new DTM file will be created. One could also right click on the surface name in the InRoads Explorer and select Save from the menu.
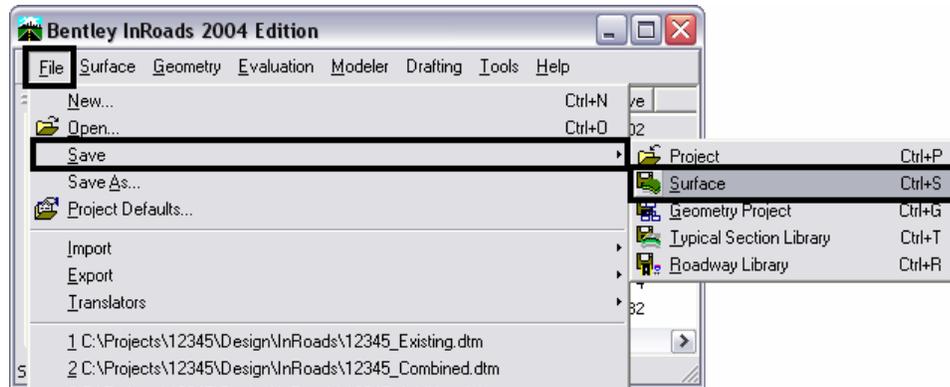
31. The **Save As** dialog box will display. Use the **Save In** drop-down to specify the desired folder for the DTM.

    Next the file name must be specified. There are two ways to do this; one, by keying in a filename (not recommended), or two, by selecting the surface from the **Active** list at the bottom of the dialog box. Selecting the surface from the **Active** drop-down will ensure that the DTM has the same name in InRoads memory as it does on the hard drive.

32. Select the down arrow on the **Active** drop-down then highlight the desired surface. This should be done even if the desired surface is already displayed in the **Active** drop-down. Selecting the surface in the **Active** drop-down will auto-populate the **File Name** field with the surface name.

33. **<D> Save** to add the file to the 'Save In' directory. After the file has been saved the **Save As** dialog box can be dismissed (**<D> Cancel**).
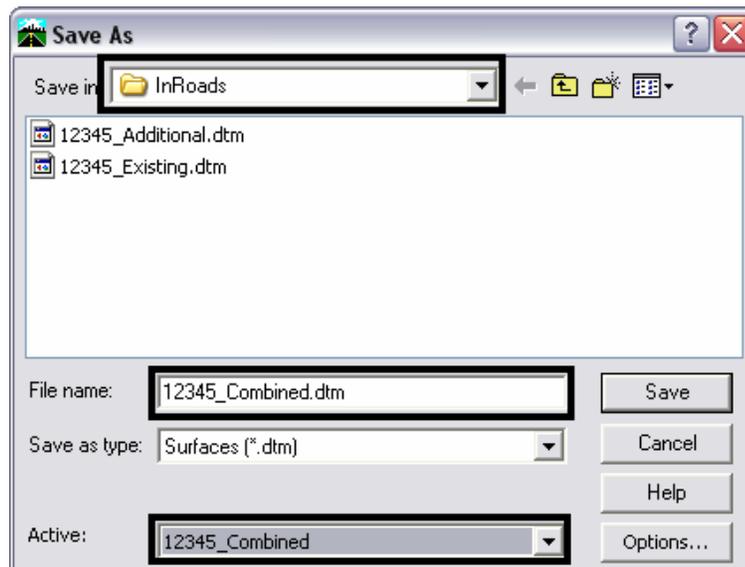
Copy a Portion of a Surface

There may be occasions when only a portion of a surface is needed. For example, one might wish to extend their existing dtm with a few hundred feet from an adjacent project or perhaps specific features from one surface are required in another. Both copying an area of a surface, and copying whole features can be accomplished using the **Copy Portion of Surface** command.

Two examples will be used to illustrate the **Copy Portion of Surface** command. In the first, all of the features within a given area will be copied into a new surface. In the second example specific features will be copied into a new surface.

Example 1 – creating a subset of a DTM

In this example, all of the surface data in the box will be copied to create a new surface.

1. A MicroStation fence is used to identify the data to be copied. Select the **Place Fence** command from the MicroStation Main toolbar. Place the fence around the area to be copied. The blue box in the illustration below shows the location of the fence.
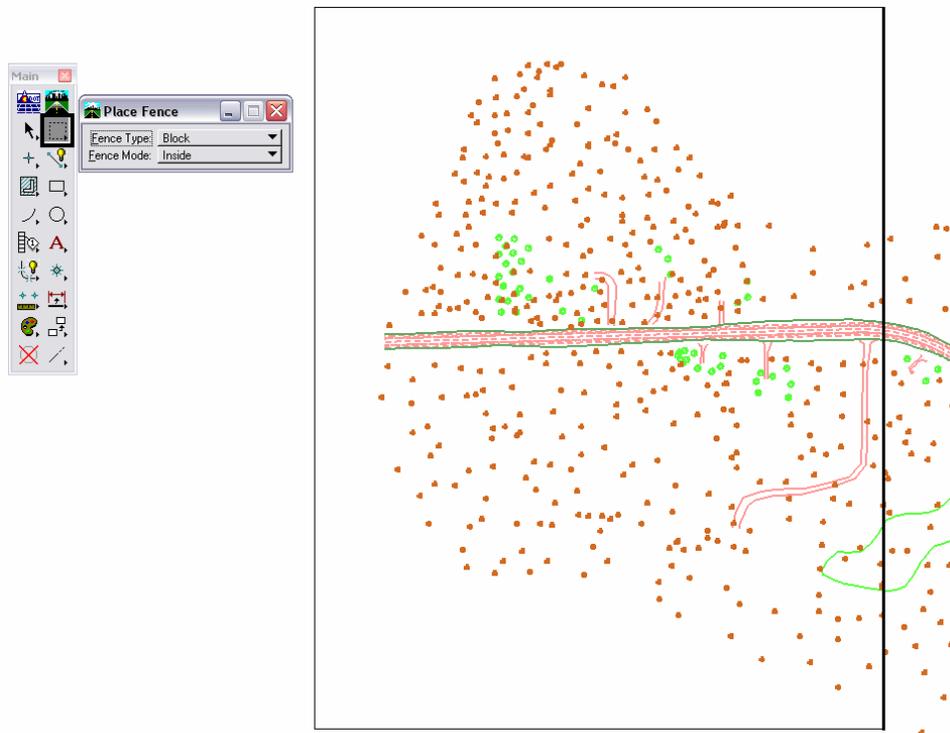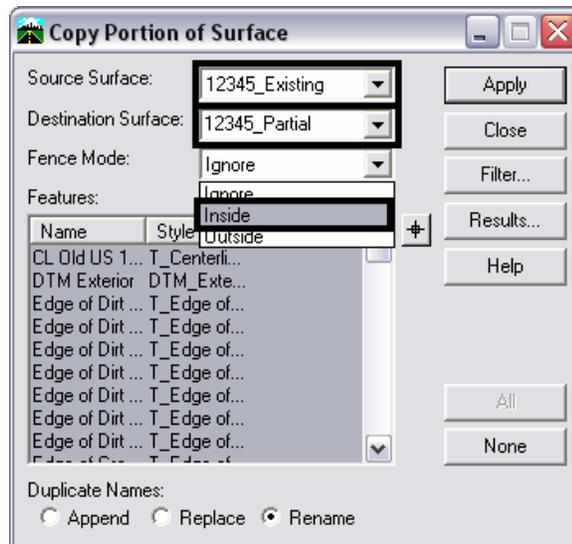

2. From InRoads, select **Surface > Edit Surface > Copy Portion of Surface**. The **Copy Portion of Surface** dialog box is displayed.
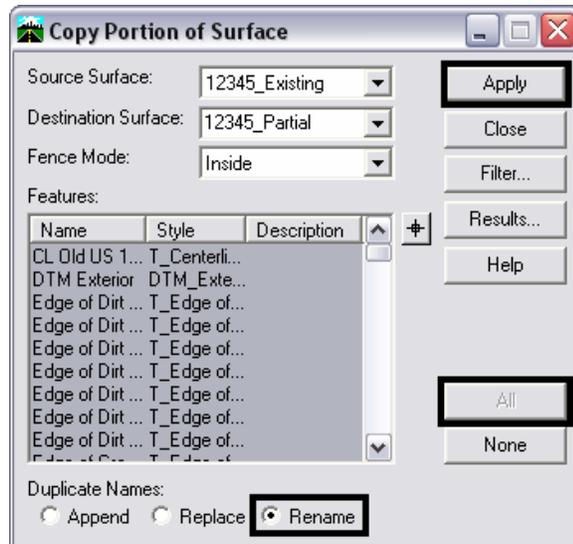
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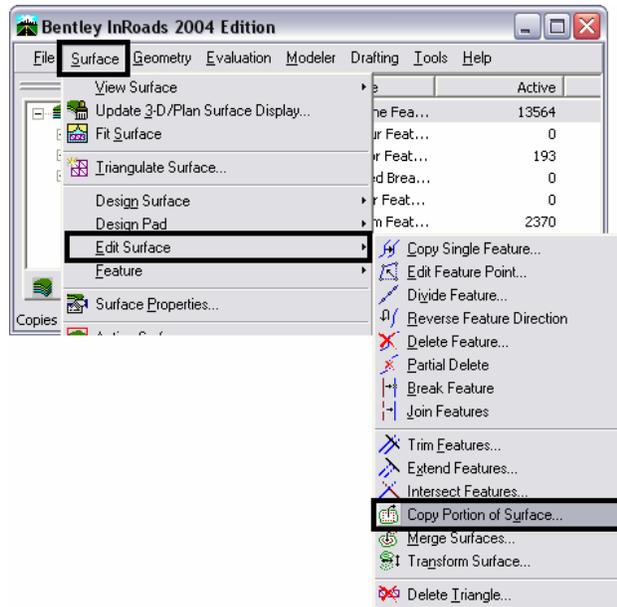
3. In the **Copy Portion of Surface** dialog box, from the **Source Surface** drop-down list select the surface to be copied from.

4. From the **Destination Surface** drop-down list select the surface to be copied to. If the surface does not exist, the name for the new surface can be keyed in here.

5. Select *Inside* from the **Fence Mode** drop-down.

6. To select all the features from the **Features** list box, **<D> All** if it is not grayed out.

7. For **Duplicate Names**, toggle on the **Rename** option.

8. **<D> Apply** to initiate the command. The **Copy Portion of Surface** dialog box will minimize then reappear when the process is completed. Dismiss the dialog box.

From the InRoads dialog box, select File > Save > Surface and save the surface. The newly created surface is now ready for use once it's been triangulated.

Example 2 -Copying a single element or multiple elements

In this example, the *Edge of Gravel Road* features will be copied into a new surface. The fence will not be used in this example because the whole feature is to be copied.

9. From InRoads, select Surface > Edit Surface > Copy Portion of Surface. The Copy Portion of Surface dialog box is displayed.

10. In the Copy Portion of Surface dialog box, use the Source Surface drop-down to select the surface to be copied from.

11. Use the Destination Surface drop-down to select the surface to be copied to. If the surface does not exist, a name to be used for the new surface can be keyed in here.

    (**Note:** the Fence Mode drop-down is grayed out because no fence is present. If a fence is present, select the *Ignore* option to copy the whole element. If the fence is defining an area to be copied or not to be copied then set the Fence Mode as needed.)

12. In the *Features* area, <D> None to deselect all of the features. Find the desired features in the list and highlight them individually. Hold the **Ctrl** key down to select a group of individual features or hold the **Shift** key to select a block of features.

13. For Duplicate Names, toggle on the Rename option.

14. **<D> Apply** to initiate the command. The **Copy Portion of Surface** dialog box will minimize then reappear when the process has completed. Dismiss the dialog box.
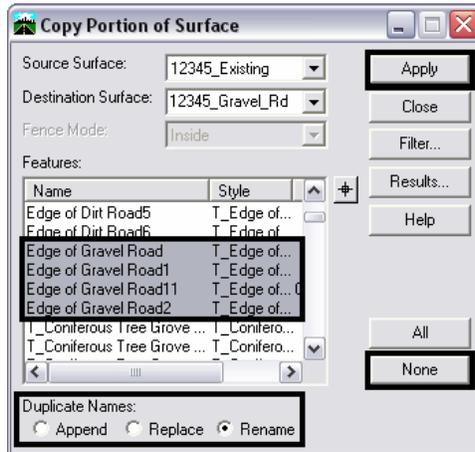
15. To verify that the data was copied, select the InRoads command **Surface > Features > Feature Properties.** The copied features should appear in the **Feature** list box.
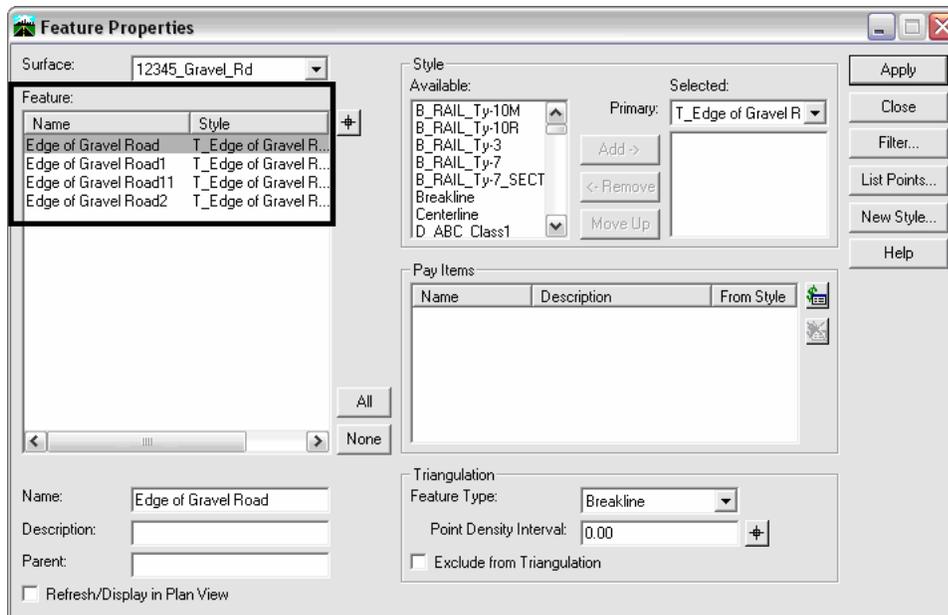
 (**Note:** the destination surfaces in the above examples were empty, newly created surfaces. However, the same process will work to copy portions of a surface into another preexisting surface. This, along with Creating an Exterior Boundary can be used to merge two adjacent, non-overlapping, surfaces.)

Note: The **Parent** field in the **Feature Properties** dialog can be populated on a feature level in their respective DTMs prior to the merging or copying of features. Doing so allows the user to *track* where data originated. Any changes made require the surface to be saved for those changes to be retained for subsequent use.