



# Road Design Tutorial

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**Product**

Surpac™ 6.6.1

Last modified: Tuesday, 1 April 2014

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# Introduction

## Overview

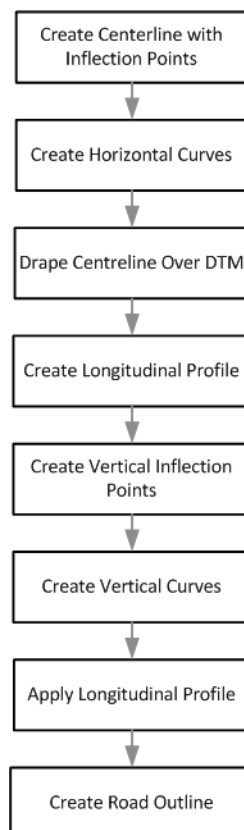
To design a simple road with few horizontal and no vertical curves, you can use the string editing tools available in the core module of Surpac. However, if you want to design a typical road that contains many horizontal and some vertical curves, use the functionality available in the road design module.


## Requirements

Before you begin this tutorial, you must have:

- a basic understanding of Surpac string files and editing tools  
It is recommended that you complete the **Introduction** tutorial prior to working through the **Road Design** tutorial.
- Surpac installed on your computer
- the data set accompanying this tutorial

## Workflow



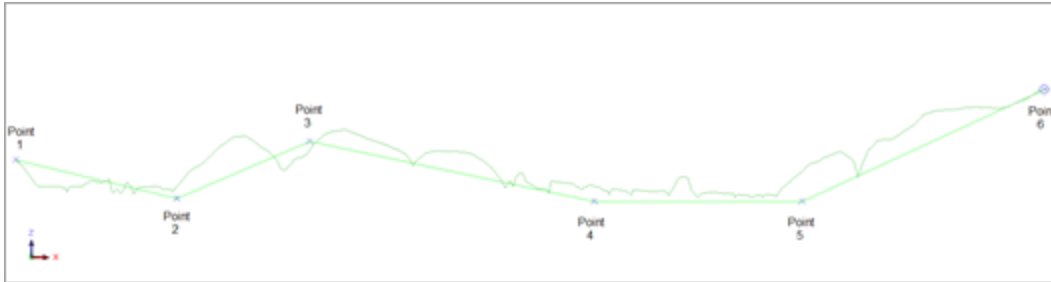
 **Note:** This workflow demonstrates the steps in this tutorial. There are other ways to achieve a result.

## Road design concepts

There are several concepts that you should understand before starting this tutorial.

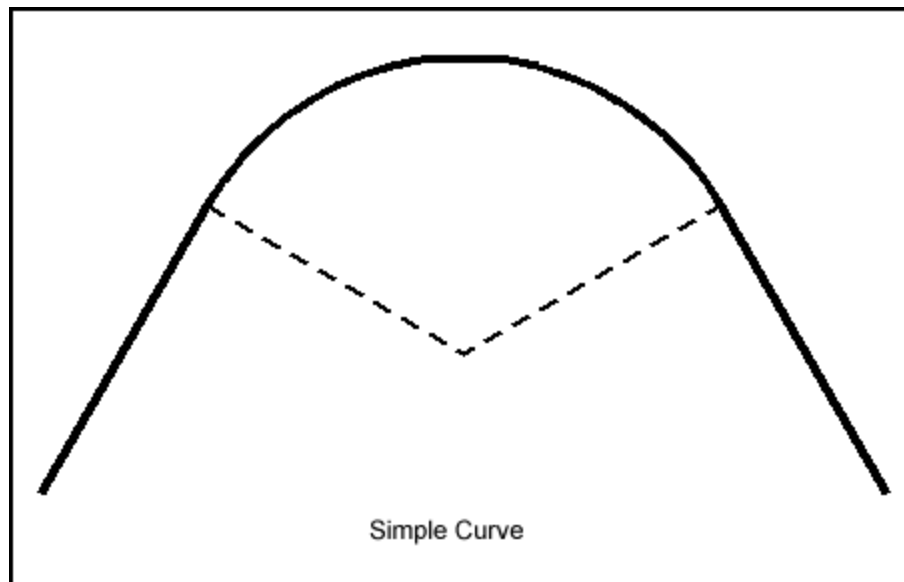
### Inflection point

Most roads are designed from inflection points, which define a change, or inflection, in the horizontal or vertical orientation of the road. The lines on either side of an inflection point define tangents to the curve.



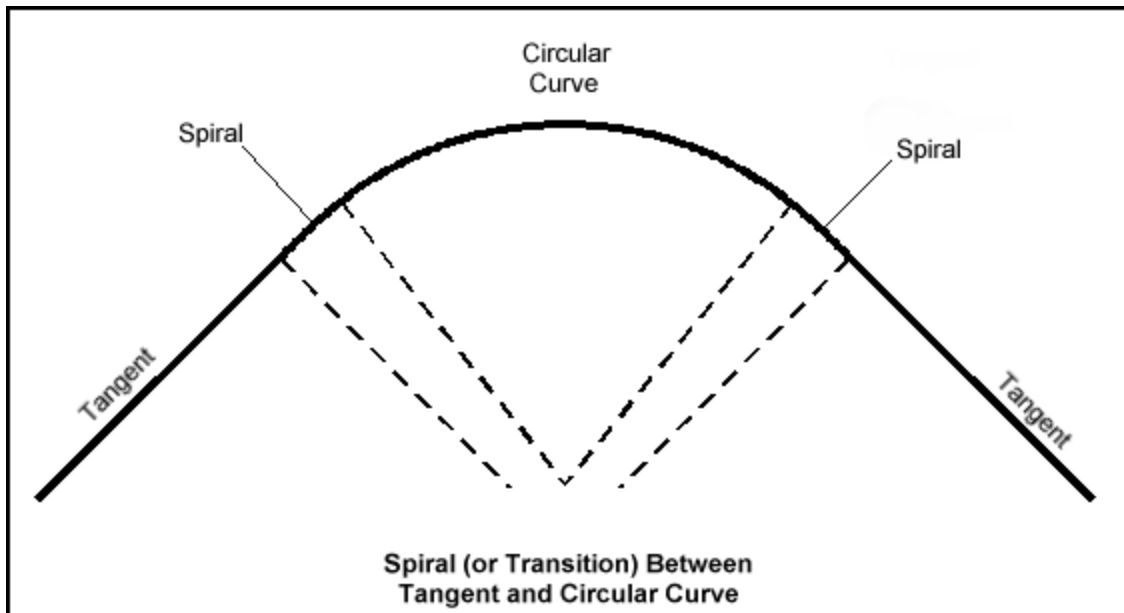
### Simple curve

A simple curve is a curve of constant radius from one tangent line to another. This curve type does not allow for transitions from the straight to the maximum curvature, and should only be used in situations where vehicle velocity is at a minimum.



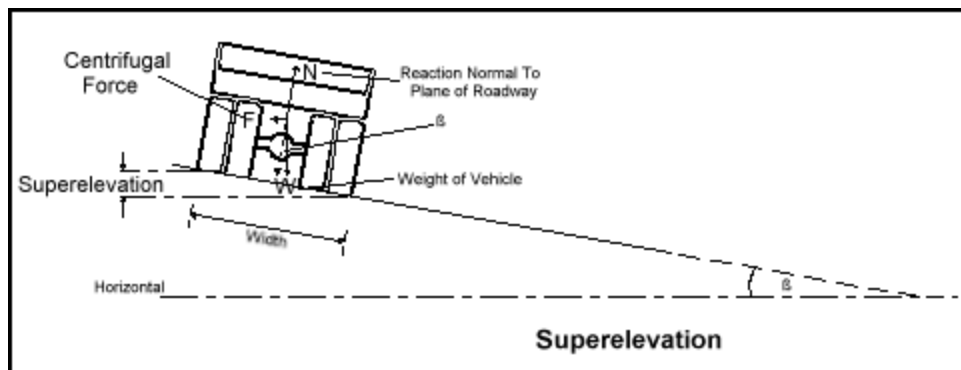
### Spiral or transition curve

This is the most common form of curve creation in Road Design. A spiral (or transition) exists between the tangent and the circular curve. This allows the vehicle to gradually increase its radius of curvature as it travels around the corner until it reaches maximum curvature.



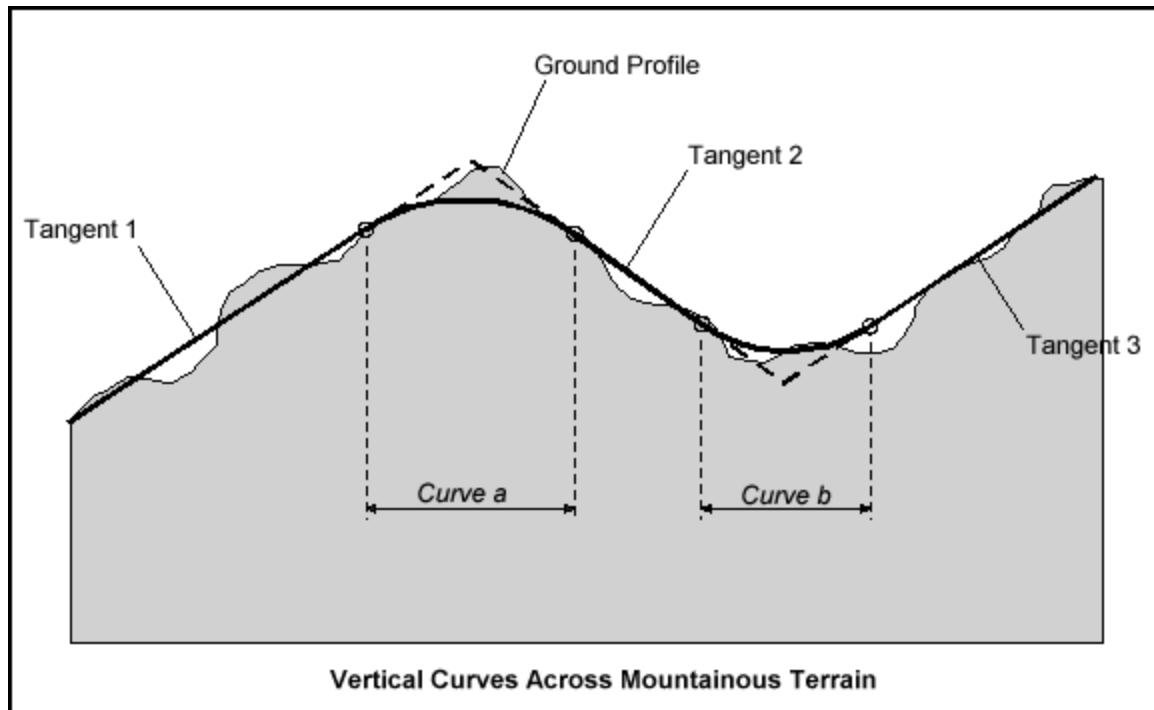
### Superelevation

The effect of centrifugal force on a vehicle as it passes through a curve must be countered by raising the outer edge. This process is known as superelevation. The outer edge is raised incrementally through the transition curve until the beginning of the circular curve where it remains constant until the exit transition curve where the outer edge is incrementally lowered.



## Vertical curve

A vertical curve exists in a vertical plane. Vertical curves consist of a simple curve with or without spiral (or transition) curves on either side.



## Setup for this tutorial

### Setting the work directory

A work directory is the default directory for saving Surpac files. Files used in this tutorial are stored in the folder `<shared_files>\demo_data\tutorials\road_design`.

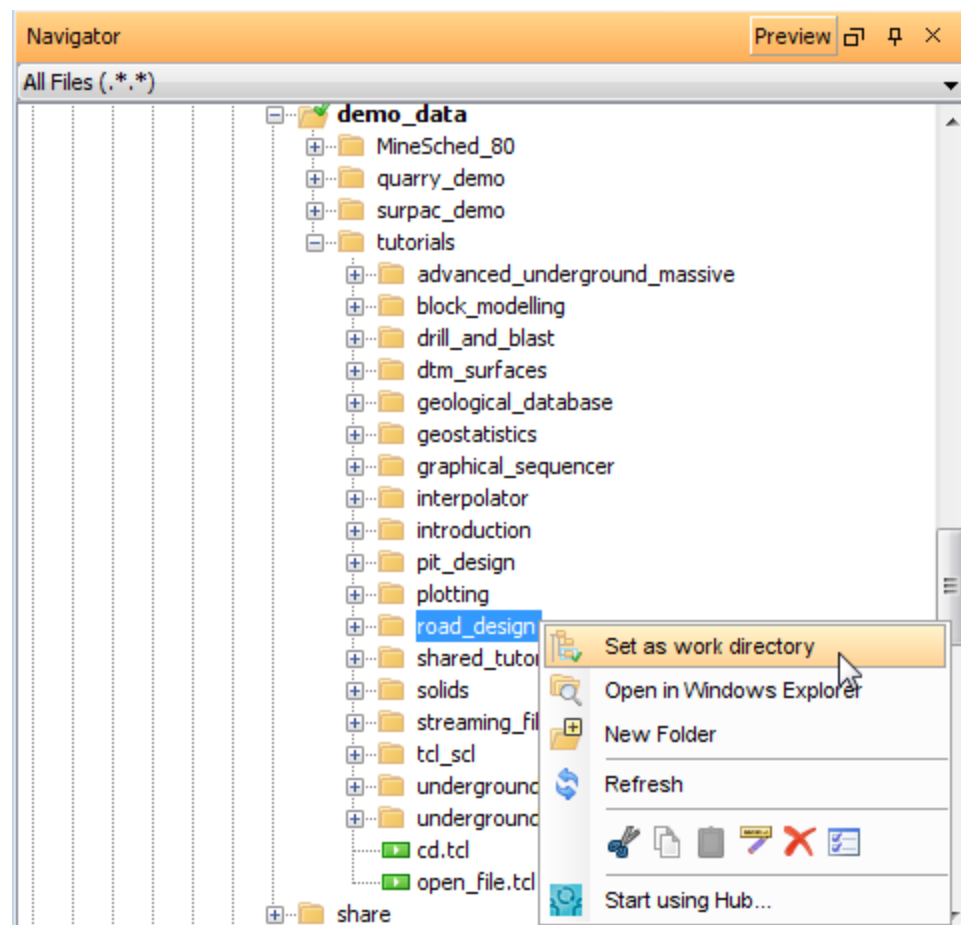
Where `<shared_files>` is the directory in which the Surpac shared files were installed.

In Windows 7, and Windows 8, the default path is

**C: \Users\Public\GEOVIA\Surpac\66\demo\_data\tutorials\road\_design.**

### Task: Set the Work Directory

1. In the Navigator, right-click the `road_design` folder.
2. From the shortcut menu, select **Set as work directory**.

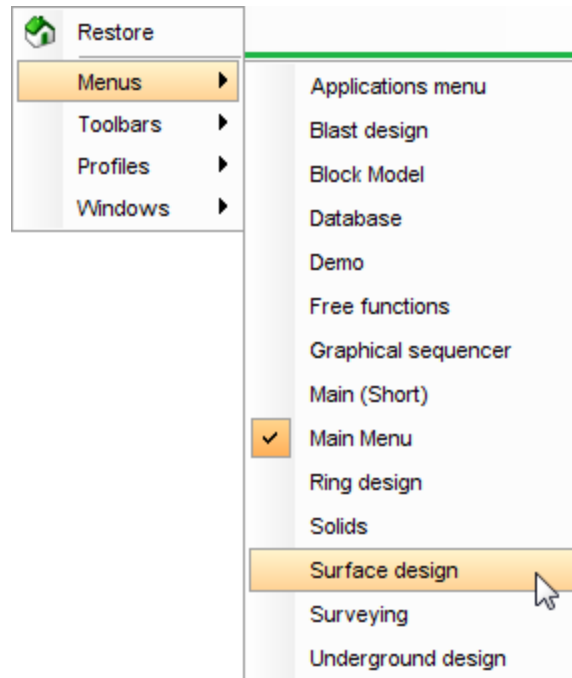


The name of the work directory is displayed in the title bar of the Surpac window.

## Displaying the menubar

### Task: Display the menus

1. Right-click in the area to the right of the menus.
2. Choose **Menu > Surface design**.



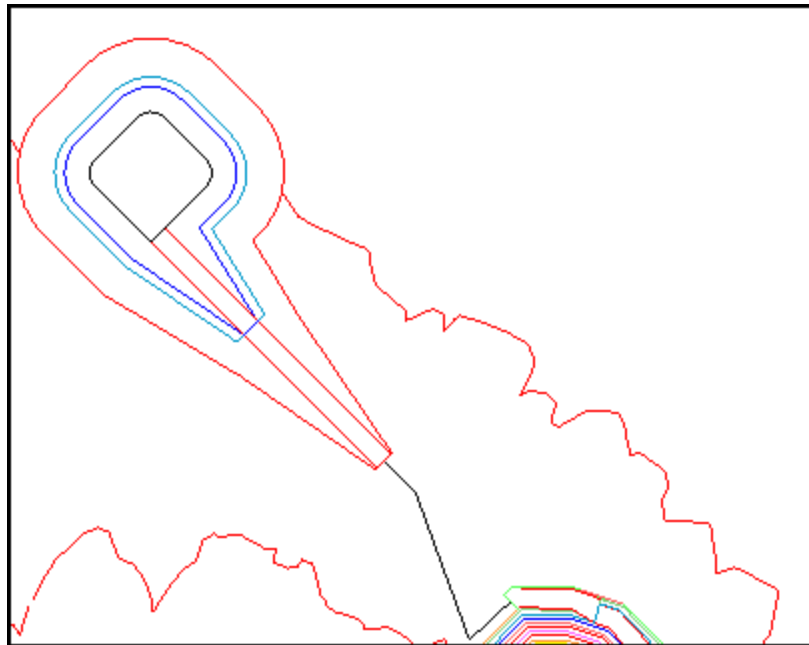
## Designing roads using string editing tools

In this chapter, you will learn how to create a road design by using simple string editing tools available in the Core Module.

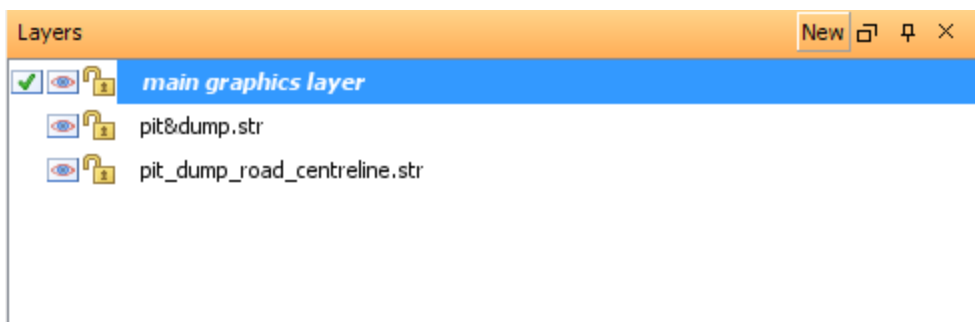
### Task: Design a road using CURVE END


In this task, you will learn how to use the function CURVE END to create a road design containing a simple horizontal curve with transition curves on either side.

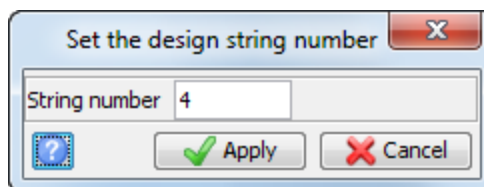
1. Click **Reset graphics** .
2. Open **pit&dump.str** in **Graphics**.
3. Open **pit\_dump\_road\_centreline.str** in **Graphics**.
4. Zoom out to view the data as shown.



5. In the **Layers** pane, double-click **main graphics layer** to set it as the default layer.

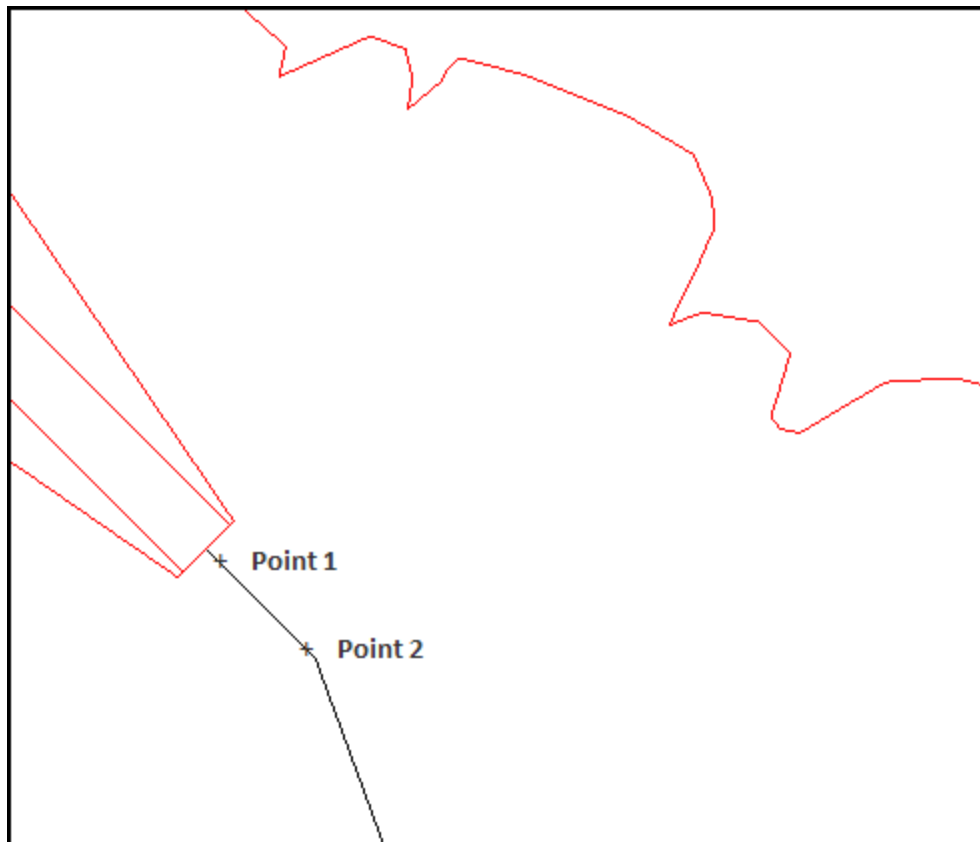


6. Click the **design string** button  on the Status bar.
7. Enter the information as shown, and click **Apply**.

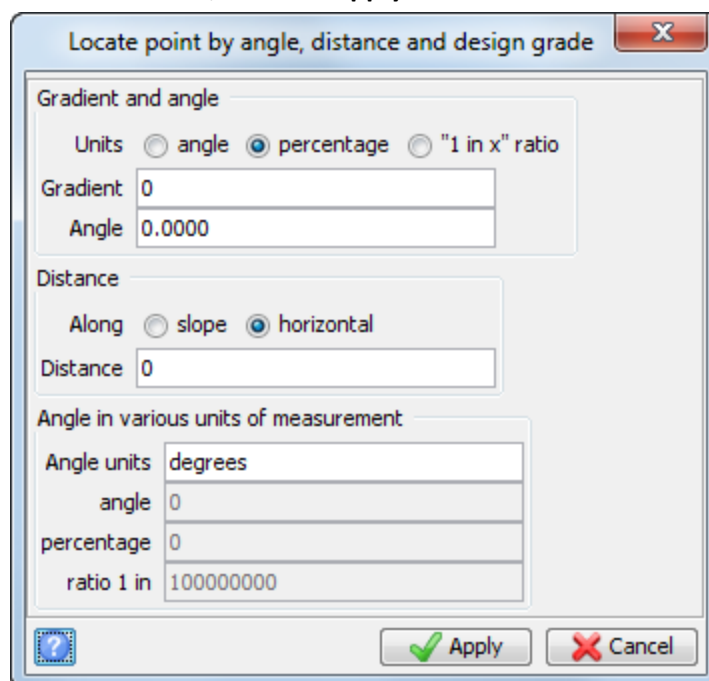


Design string number 4 will be used for the road centreline.

8. Choose **Create > Points > By angle**.
9. Click Point 1 and then Point 2, as shown.

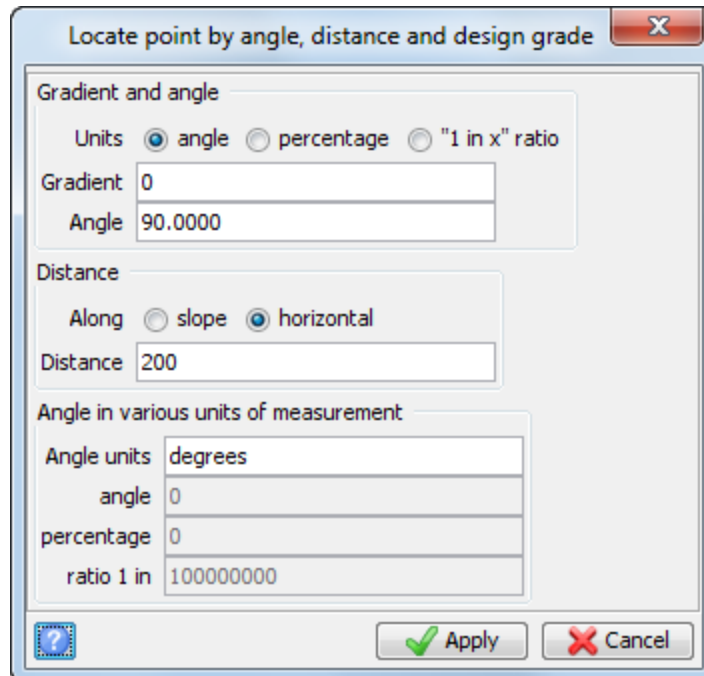


10. Enter the information as shown, and click **Apply**.



This creates the start point for the new road, which is at the same coordinates as the point near the second point selected. The point is created in string 4.

11. Click the same two points again.
12. Enter the information as shown, and click **Apply**.



Locate point by angle, distance and design grade

Gradient and angle

Units  angle  percentage  "1 in x" ratio

Gradient 0

Angle 90.0000

Distance

Along  slope  horizontal

Distance 200

Angle in various units of measurement

Angle units degrees

angle 0

percentage 0

ratio 1 in 100000000

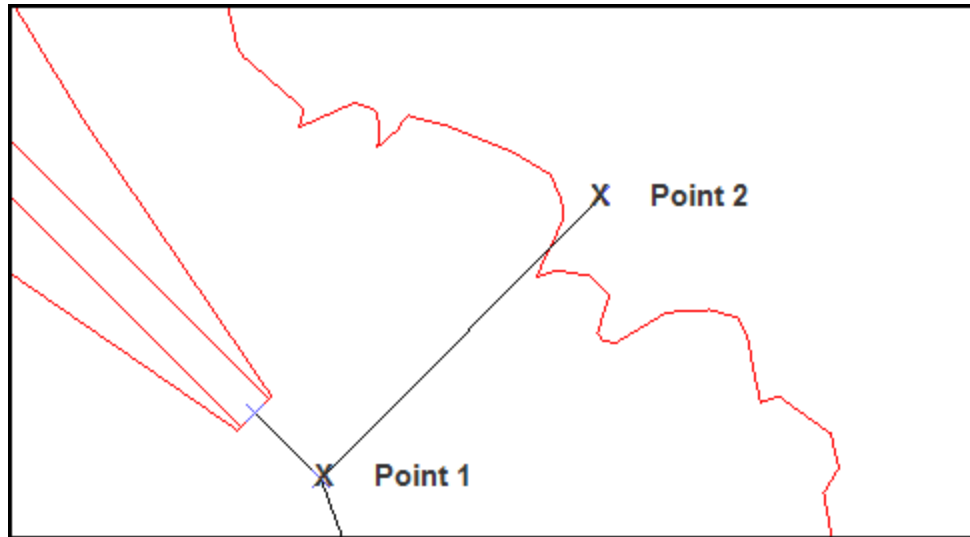
Apply Cancel

This creates the second point of the road centreline, as shown.



13. Press ESC.

14. Choose **Create > Curve at segment end**.
15. Click Point 1 and then Point 2, as shown.



16. Enter the information as shown, and click **Calculate**.

**Parameters for a curve at end of line** ✕

Direction  Clockwise  Anticlockwise

Radius

Curve  Angle  Length

Angle or Length

Arc distance

Use entry transition curve

Entry transition length

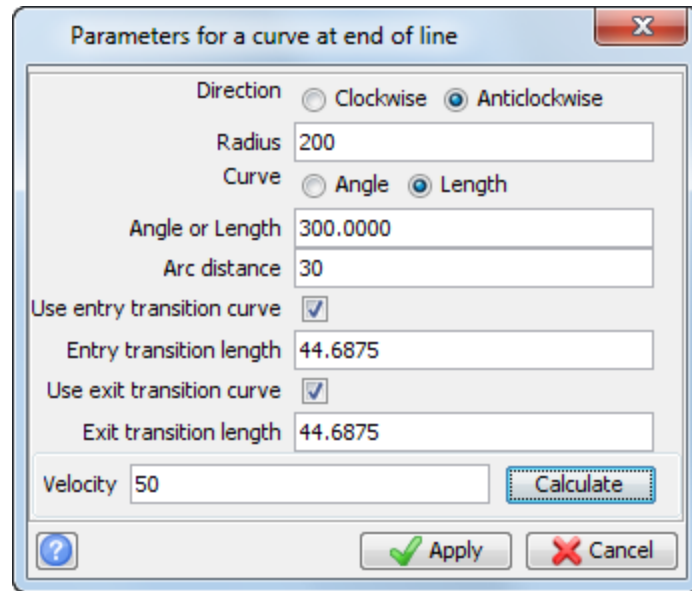
Use exit transition curve

Exit transition length

Velocity  Calculate

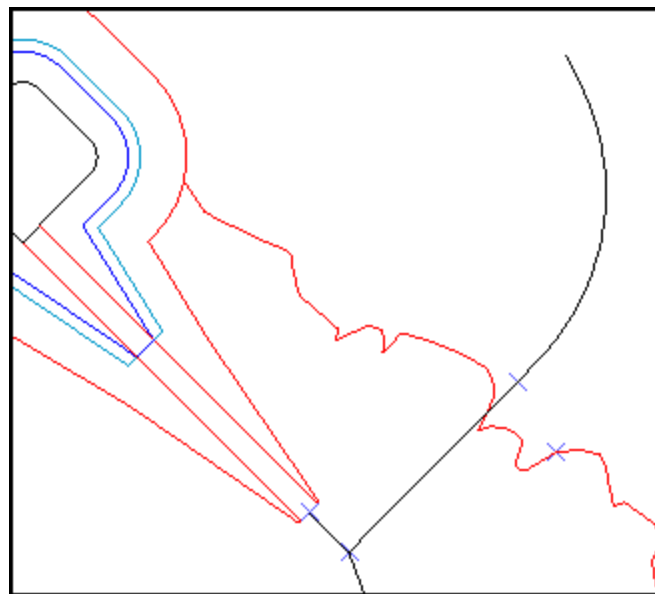
?
✔ Apply
✖ Cancel

17. After the transition lengths are calculated (as shown), click **Apply**.

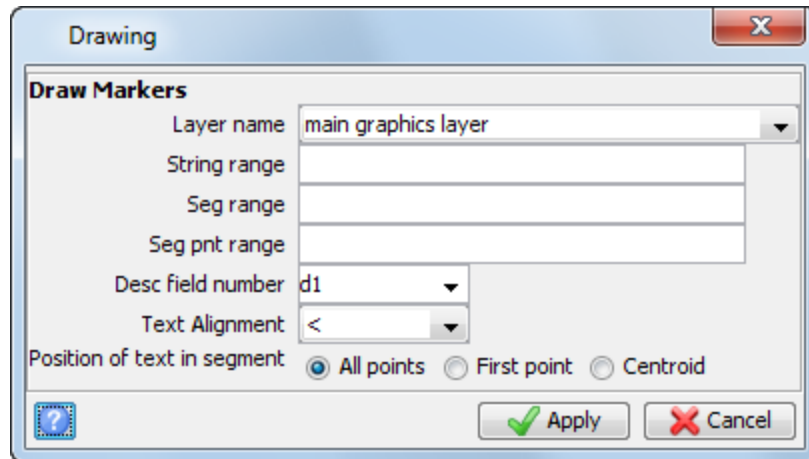



18. Press ESC.

19. Zoom into the view as shown.



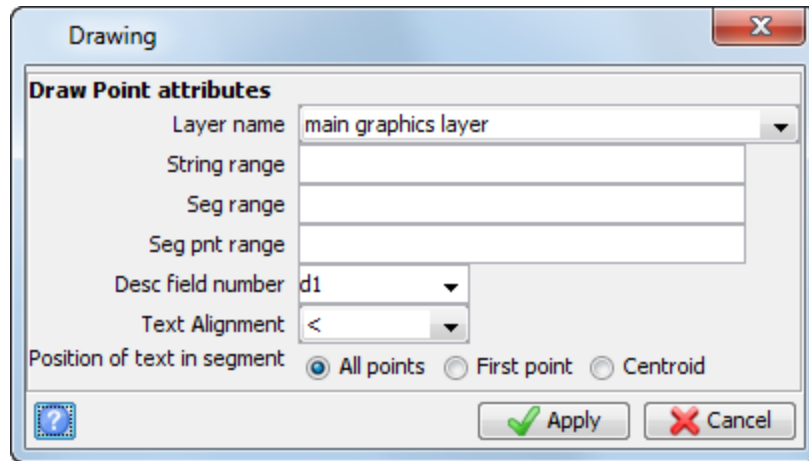
20. Choose **Display > Point > Markers**.
21. Enter the information as shown, and click **Apply**.



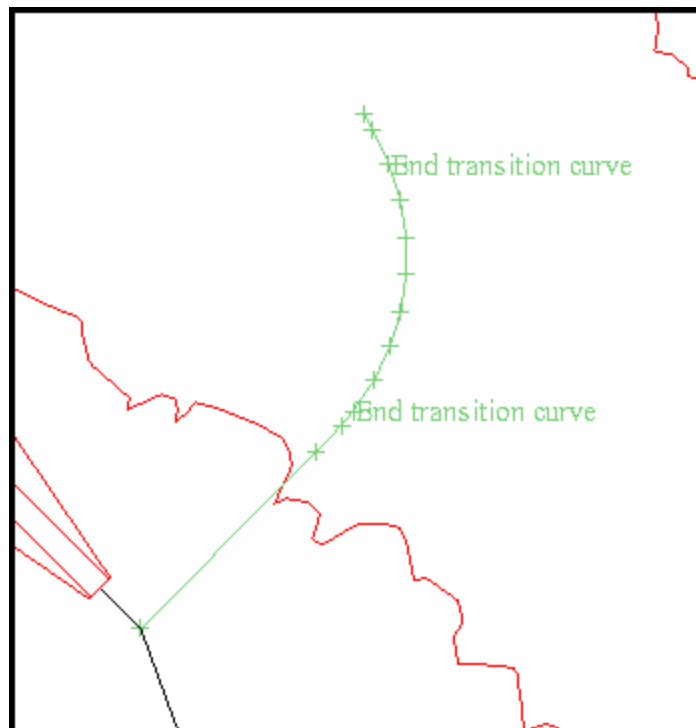
 **Note:** Points have been created every 30 metres along the arc length to approximate the curve.



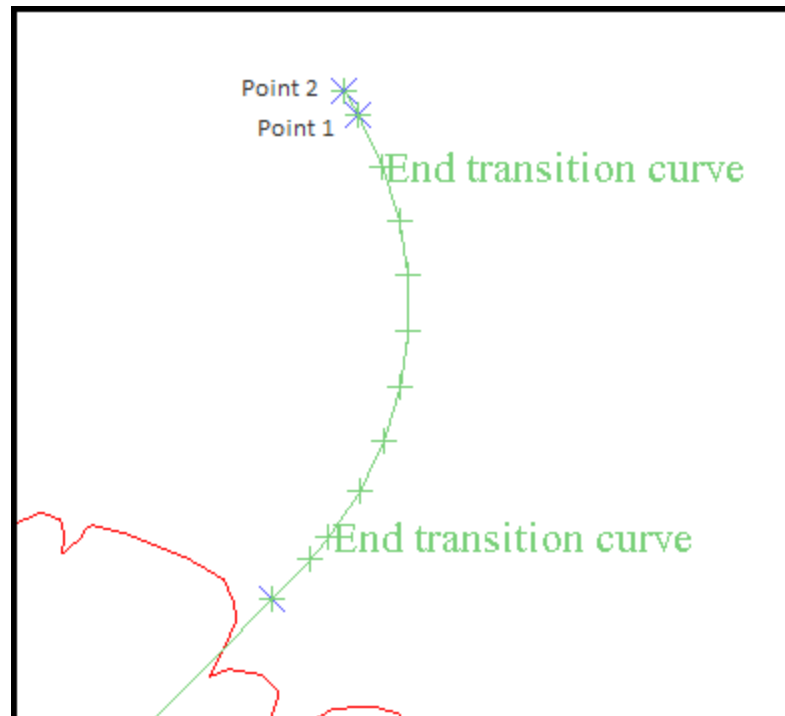
22. Choose **Display > Point > Attributes**.
23. Enter the information as shown, and click **Apply**.



**Note:** The points where the transition curve ends, and the simple curve begins have the description "End transition curve".



24. Choose **Inquire > Bearing and distance between 2 points**.
25. Click Point 1 and then click Point 2, as shown.



26. Press ESC.  
The bearing from Point 1 to Point 2 is displayed in the message window, as shown.

```
From (Y=1514.01 X=224.00 Z=997.72) to (Y=1526.95 X=217.06 Z=997.72):
Bearing = 331.820 decimal degrees = 331.4910 DMS, Horiz Dist = 14.688
Slope dist = 14.688, Vert Dist = 0, Gradient: 0 decimal degrees = 0 DMS = 0 % = 1 in 100000000
```

Next, the road centreline will be extended at this bearing.

27. Choose **Create > Points > By bearing**.
28. Click the end of the curve (Point 2 in the previous image).
29. Enter the information as shown, and click **Apply**.

Locate point by bearing,distance and design grade

Gradient and angle

Units  angle  percentage  "1 in x" ratio

Gradient 0

Bearing 331.4910

Distance

Along  slope  horizontal

Distance 200

Angle in various units of measurement

Angle units degrees

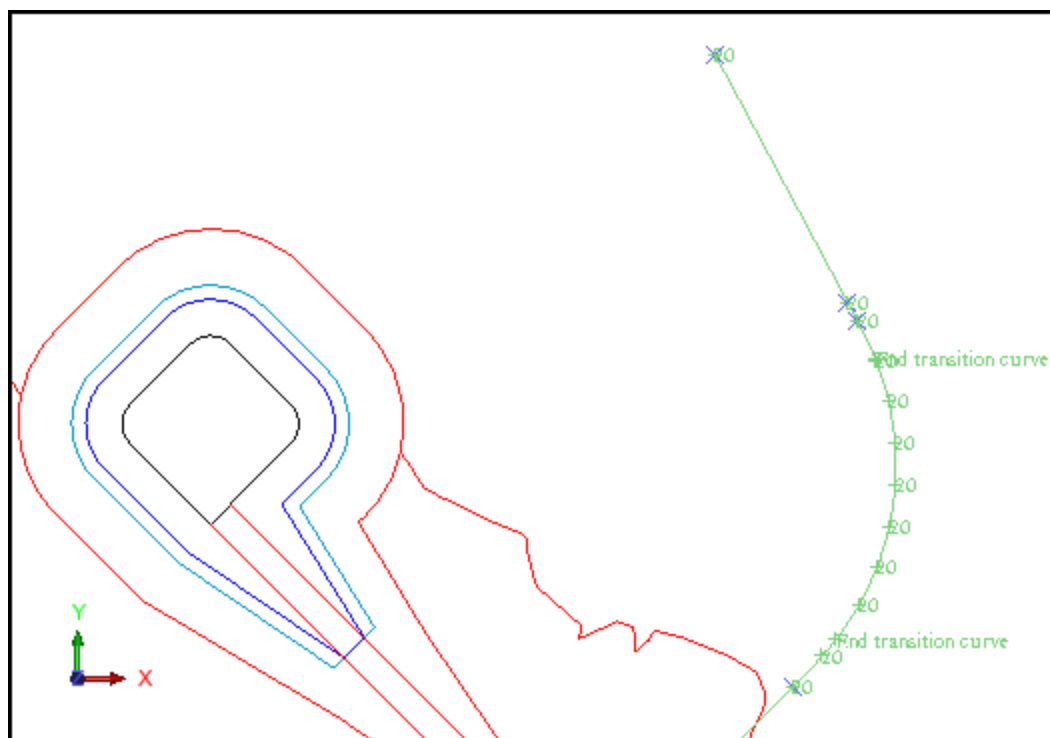
angle 0

percentage 0

ratio 1 in 100000000

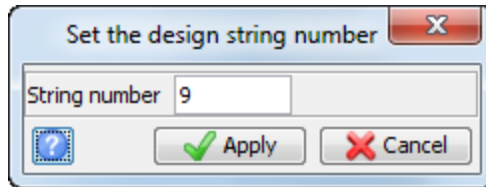
Apply Cancel

30. Press ESC.  
The road centreline is extended horizontally 200 metres at the bearing of 331 degrees, 49 minutes, 10 seconds, as shown.



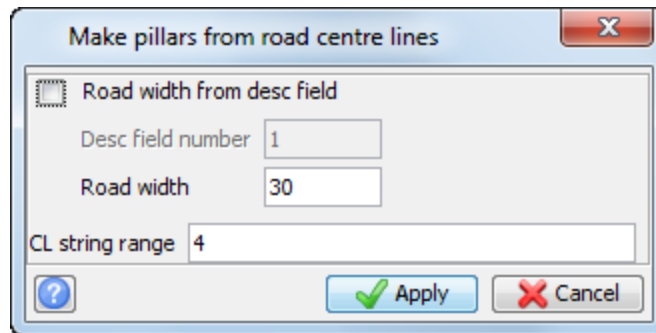
The centreline design is complete. The next step is to create the road outline.

31. Click the **design string** button **Str = 4** on the Status bar.
32. Enter the information as shown, and click **Apply**.

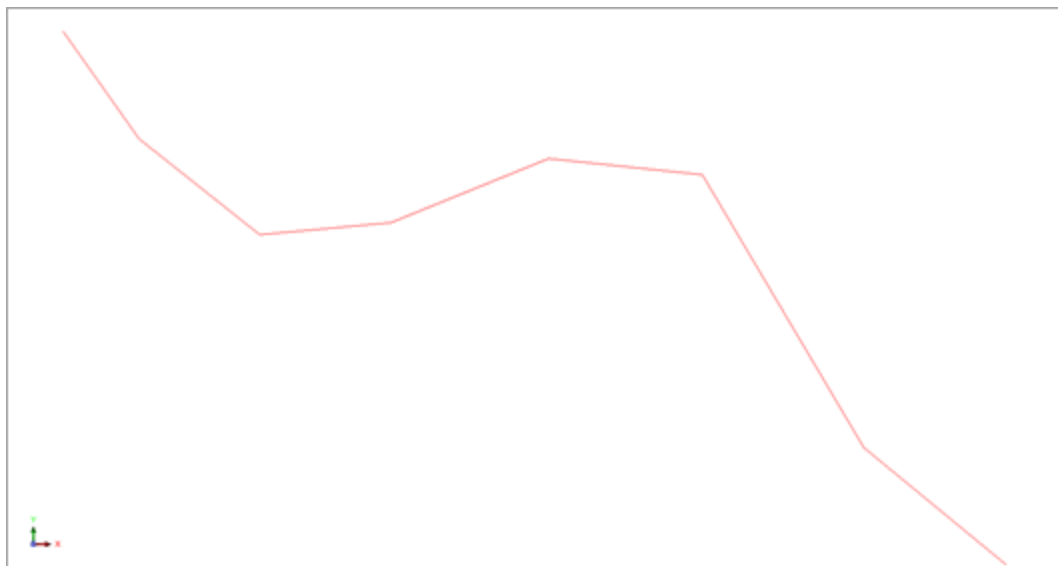



The design string number of 9 will be used for the road outline.


33. Choose **Design > Underground tools > Room & pillar from centrelines**.
34. Enter the information as shown, and click **Apply**.

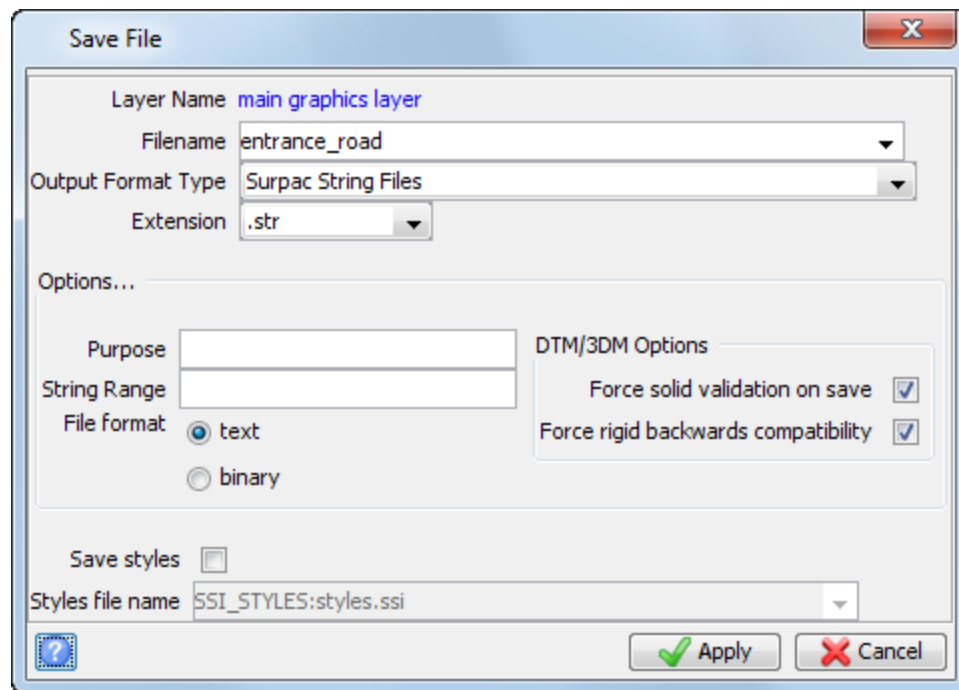


The road outline is created, as shown.



 **Note:** The function **MAKE PILLARS** is used to create the road outline in this example.

35. Click **Save** .
36. Enter the information as shown, and click **Apply**.



**Note:** To see all the steps performed in this section, run `1a_curve_end.tcl`. You need to click **Apply** on any forms presented.

### Task: Design a road using CURVE TANGENT

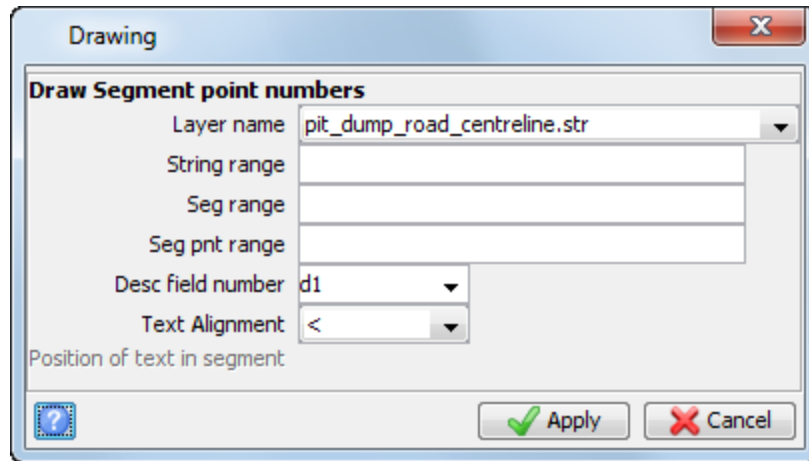
In this task, you will learn how to use the function CURVE TANGENT to create a road design from a centreline string that contains an inflection point.

1. Click **Reset graphics** .
2. Open `pit&dump.str` in **Graphics**.
3. Open `pit_dump_road_centrelines.str` in **Graphics**.  
Zoom into the view as shown.

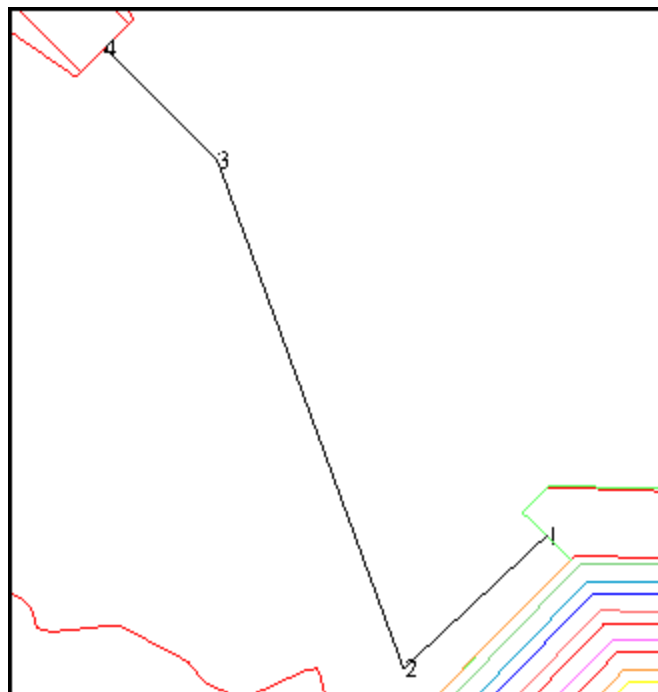


4. Choose **Display > Point > Numbers**.

5. Enter the information as shown, and click **Apply**.

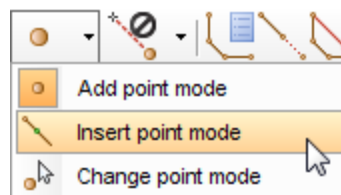


The point numbers are displayed, as shown.



**Note:** It is not necessary to display the point numbers. This is done in this example to identify the points to select.

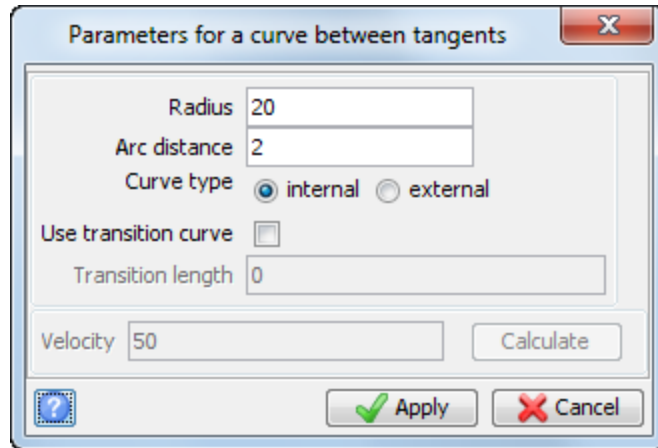
6. From the mode selector, choose **Insert point mode**.



**Note:** The insert mode will result in points inserted within the centreline string when the curve is created.

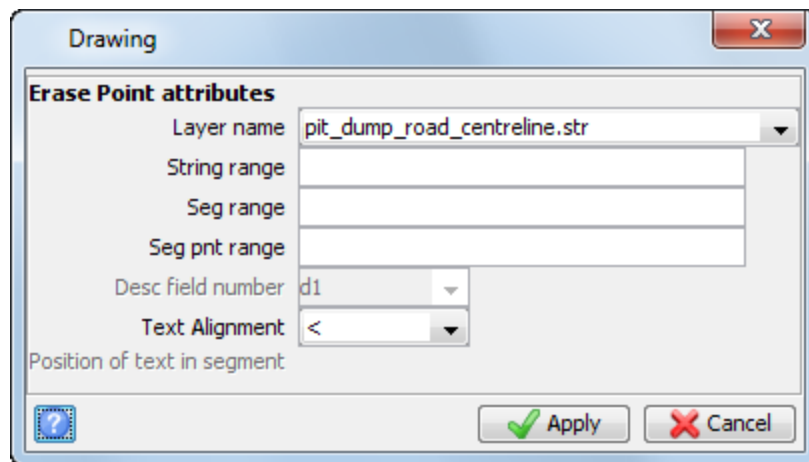
7. Choose **Create > Curve from tangents**.
  8. Click Point 1 and then Point 2.
- Note:** The line connecting points 1 and 2 define the first tangent.

9. Click Point 2 (again) and then Point 3.  
✎ **Note:** The line connecting points 2 and 3 define the second tangent.
10. Enter the information as shown, and click **Apply**.

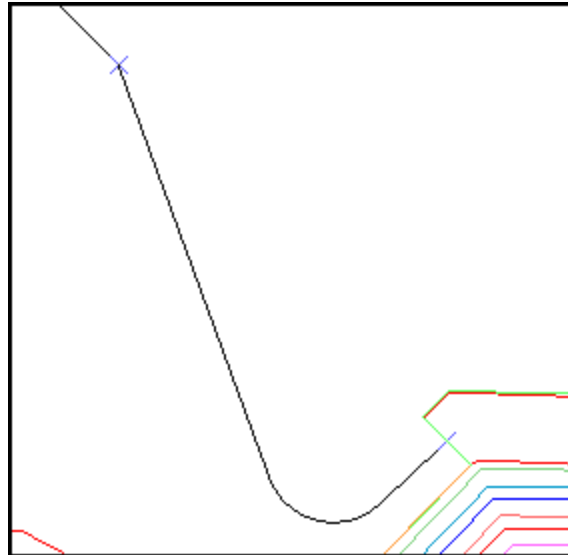


✎ **Note:** In this example, a simple curve is created because you have not selected **Use transition curve**.

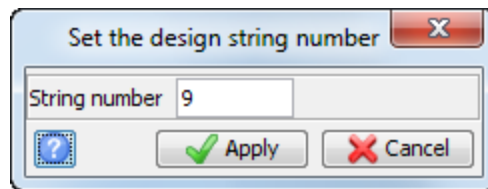
11. Press ESC.
12. Choose **Display > Hide point > Attributes**.
13. Enter the information as shown, and click **Apply**.



You should now see the curve as shown, created between the two tangents.

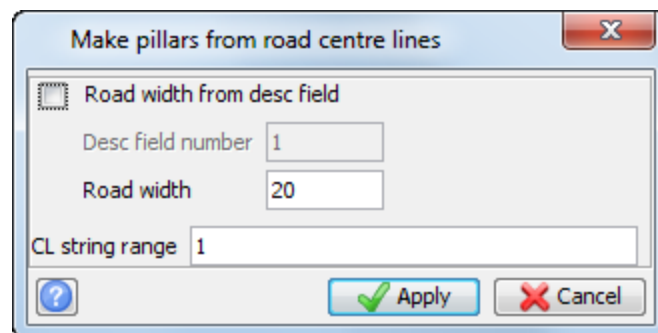


14. Click the **design string** button **Str = 1** on the status bar.
15. Enter the information as shown, and click **Apply**.

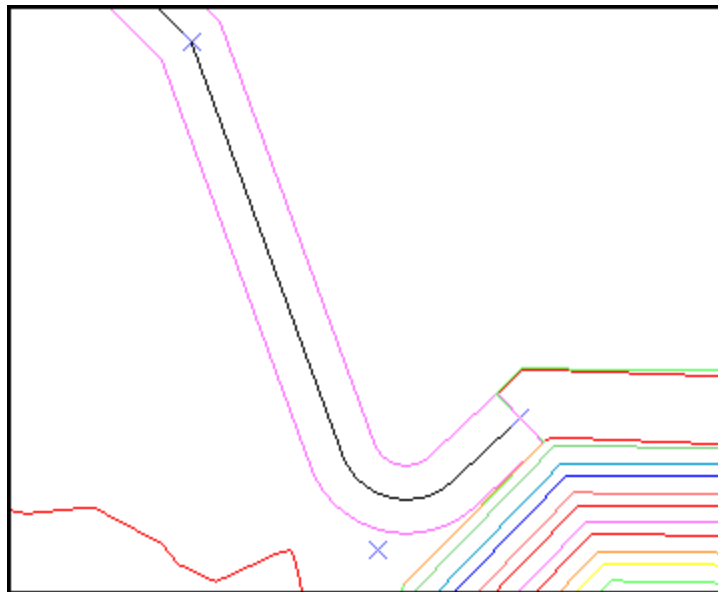


The design string number of 9 will be used for the road outline.

16. Choose **Design > Underground tools > Room & pillar from centrelines**.
17. Enter the information as shown, and click **Apply**.



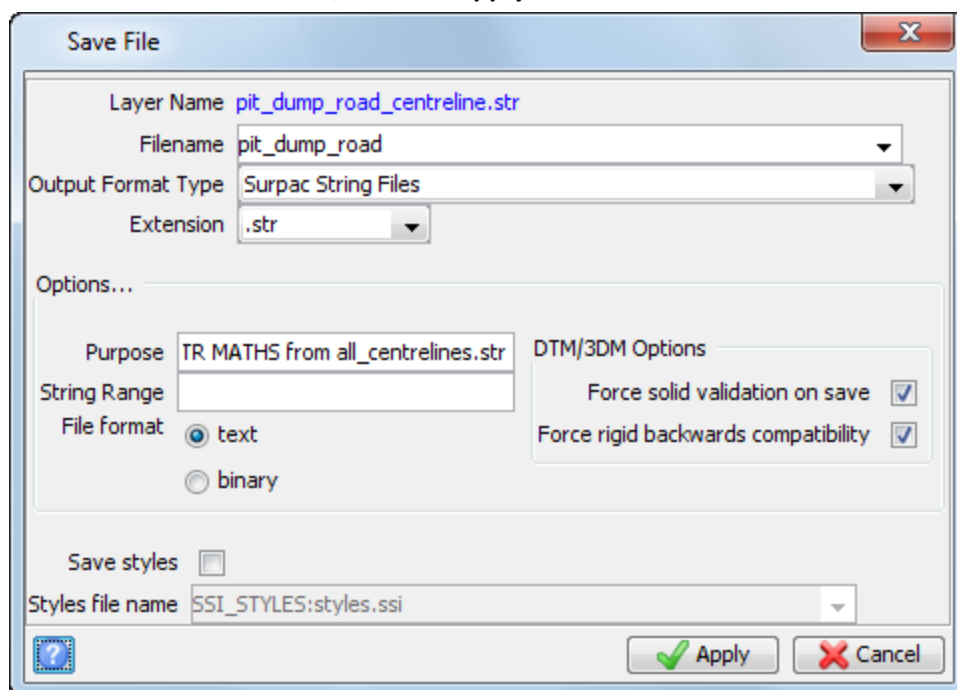
The road outline is created, as shown.



**Note:** The function **MAKE PILLARS** is used to create the road outline in this example, as the function is a part of the Core Module.

18. Click **Save** .


19. Enter the information as shown, and click **Apply**.

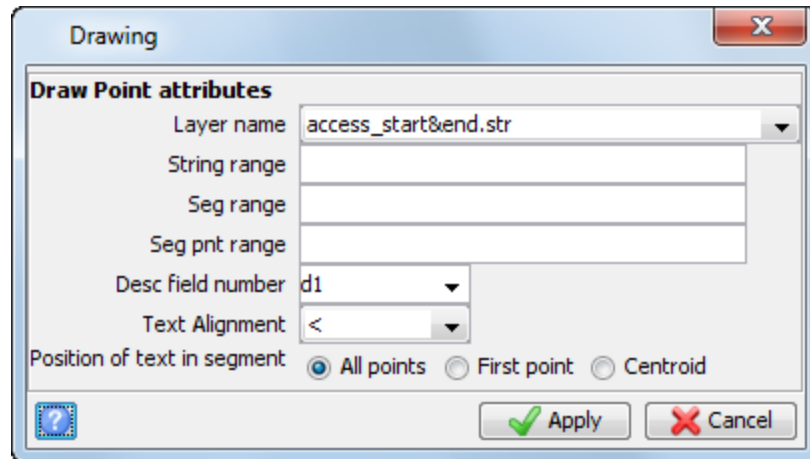


**Note:** To see all the steps performed in this section, run **1b\_curve\_tangent.tcl**. You need to click **Apply** on any forms presented.

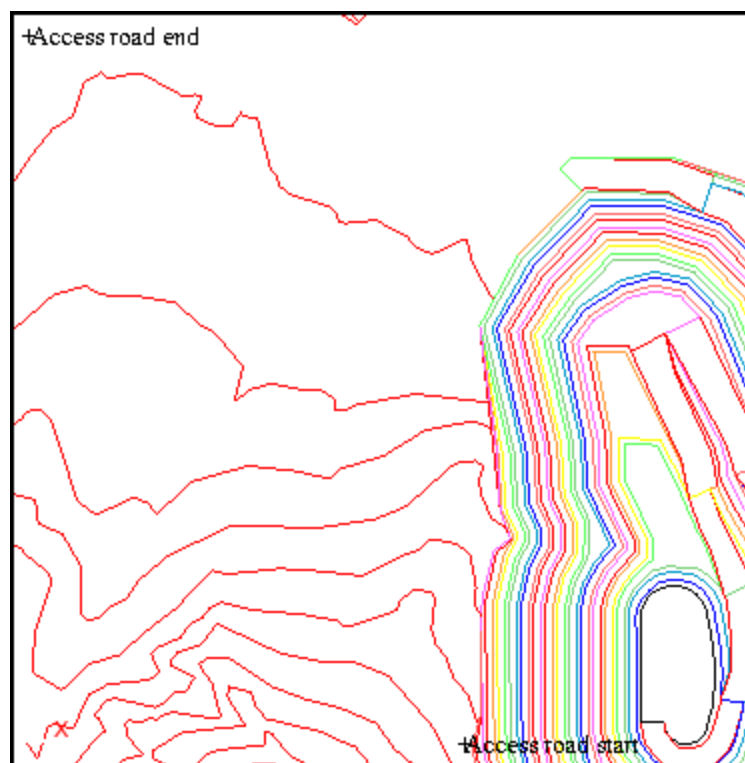
### Task: Design a road at a Constant Gradient Along Contours

In this task, you will create an access road with a maximum gradient of 5%. The road design will be based on a string file of topography contours.

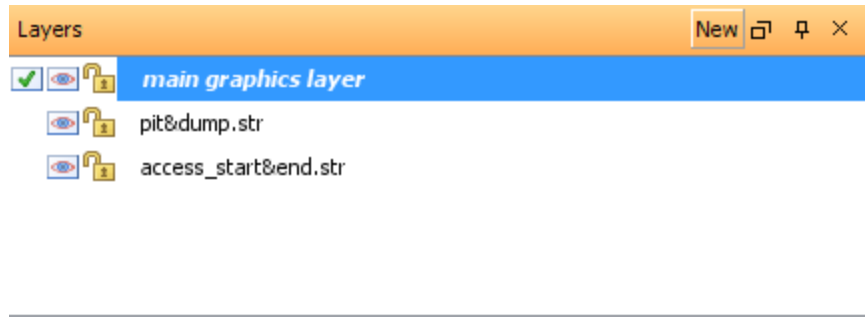
1. Click **Reset graphics** .
2. Open **pit&dump.str** in **Graphics**.
3. Open **access\_start&end.str** in **Graphics**.
4. Choose **Display > Point > Attributes**.
5. Enter the information as shown, and click **Apply**.



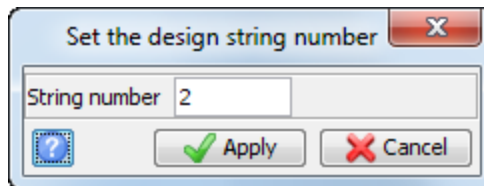
In this example, the goal is to create the shortest, straightest road possible between these two points, while ensuring that the maximum gradient is not more than 5%.



6. In the **Layers** pane, double-click **main graphics layer** to set it as the default layer.

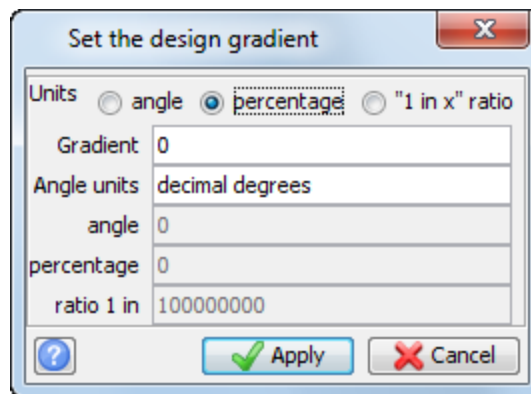


7. Click the **Design string** button `Str = 1` on the Status bar.
8. Enter the information as shown, and click **Apply**.



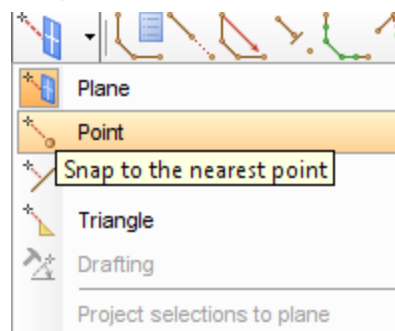
The design string number 2 will be used for the road centreline.

9. Click the design grade button `0.000 angle` on the Status bar.
10. Enter the information as shown, and click **Apply**.

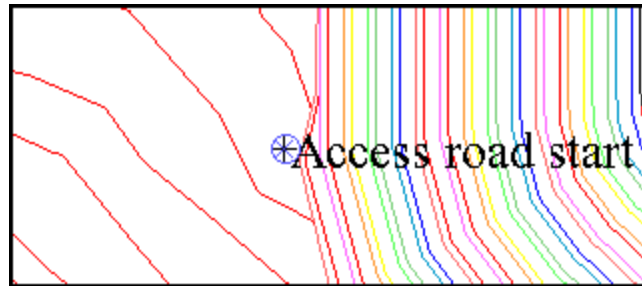


**Note:** In this example, you will not use the actual design gradient value (set to zero in the previous form) to create points. You will digitise points, and want to see the gradient between any two points expressed as a percentage. By setting the units to **percentage**, the gradient between the digitised points will be displayed as a value in percent in the Status bar.

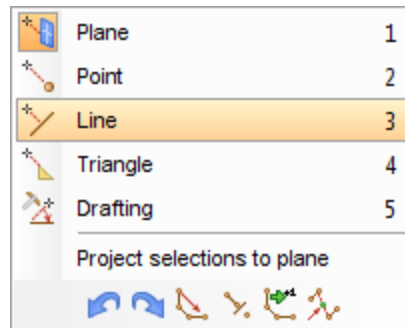
11. Choose **Create > Digitise > New point**.
12. Click the **Snap mode** drop-down, and select **Point**.



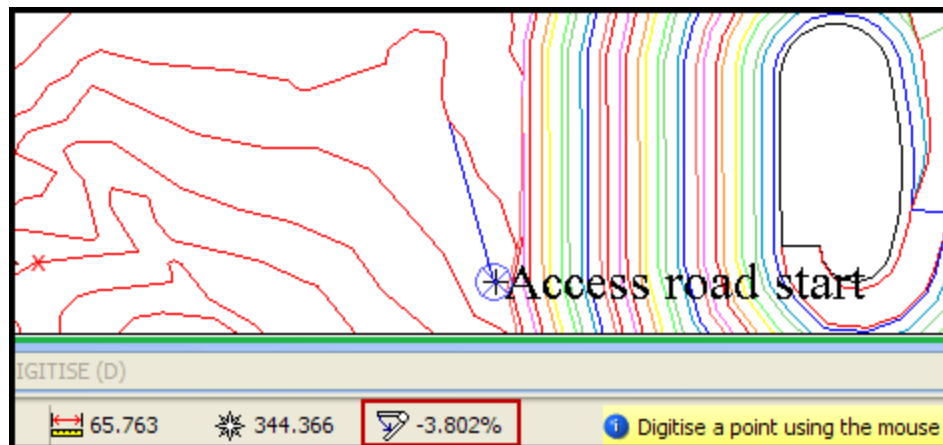
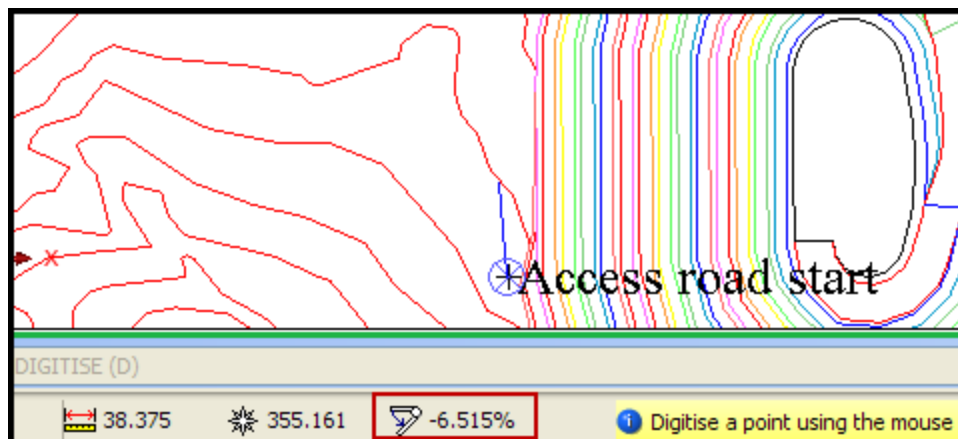
- Click the **Access road start** point as shown.



- Right-click in **Graphics**, and select **Line**.



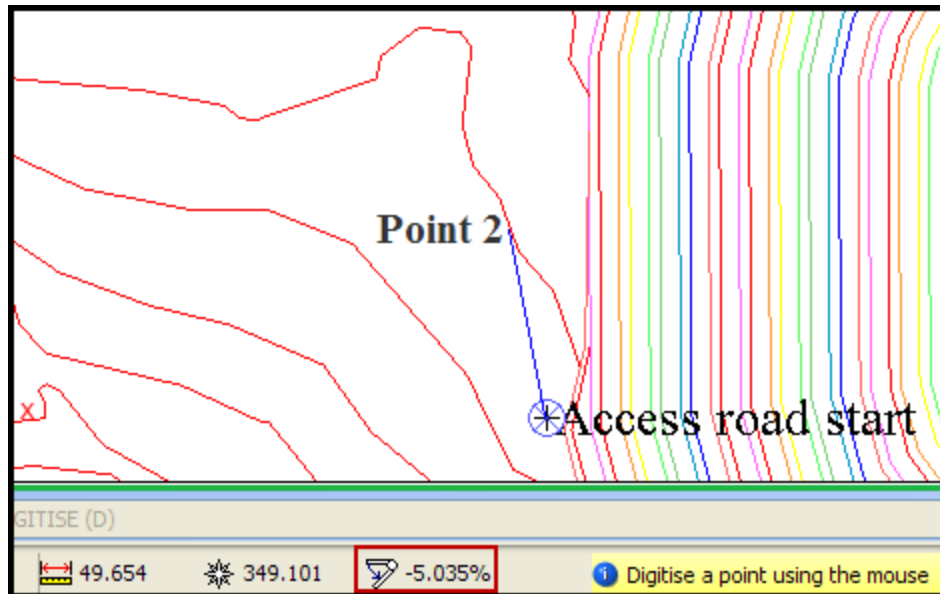
- Move the cursor along the contour as shown.



**Note:** As you move the cursor along the contour line, the gradient (expressed as a percentage in the status bar) will change. Remember that the goal is to create a road with

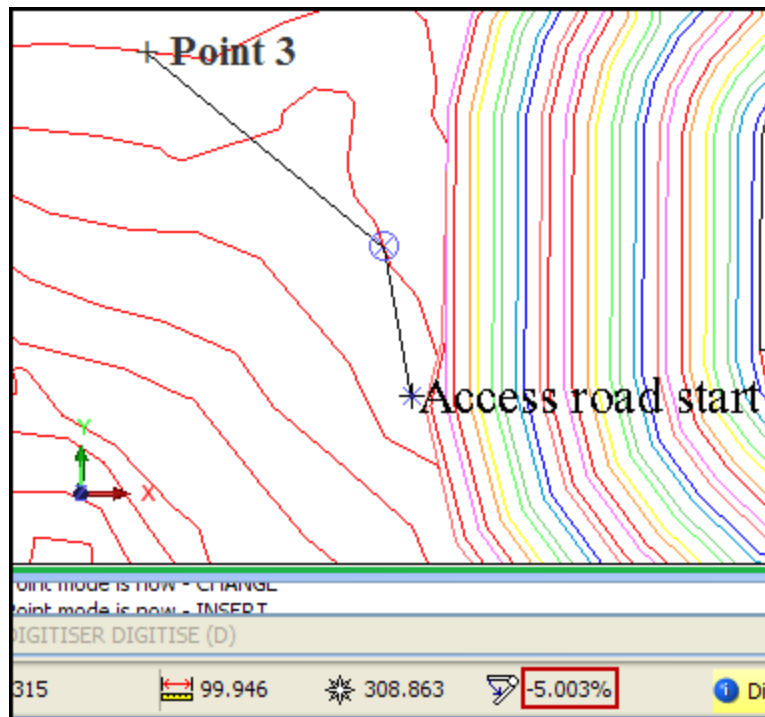
a centreline at a maximum gradient of 5%. Since we are designing from the uppermost point down, the gradient will be -5%.

- Click on the contour line near Point 2 when the percentage value displayed in the Status bar is approximately -5%, as shown.

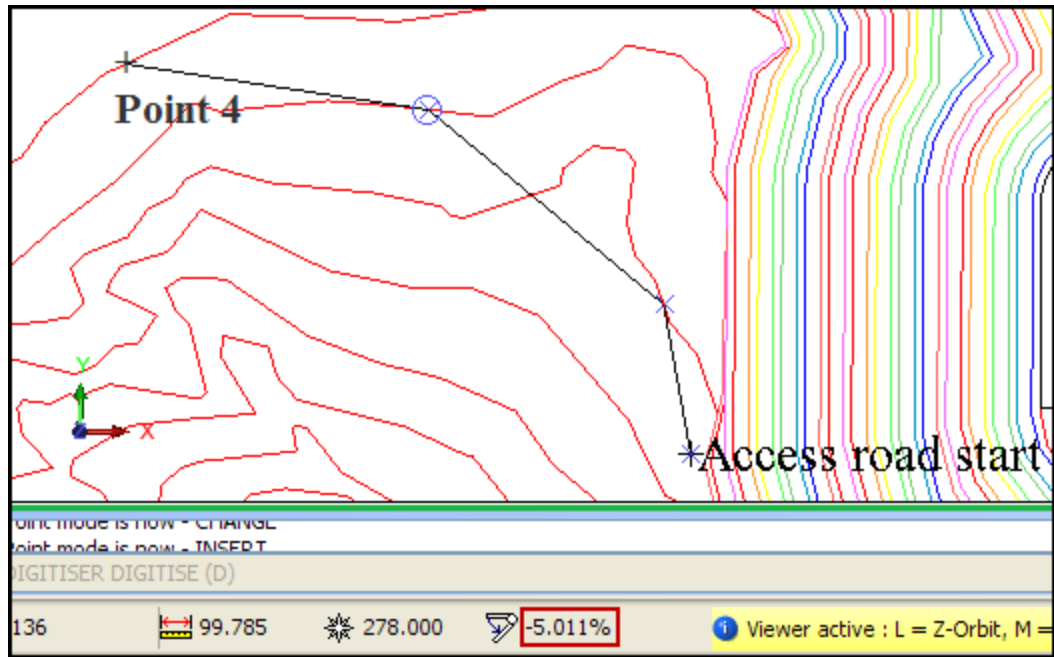


**Note:** There will be two or more locations along a contour where the gradient will be the same. In this example, the points are selected based on the desire to create a road that is as straight as possible.

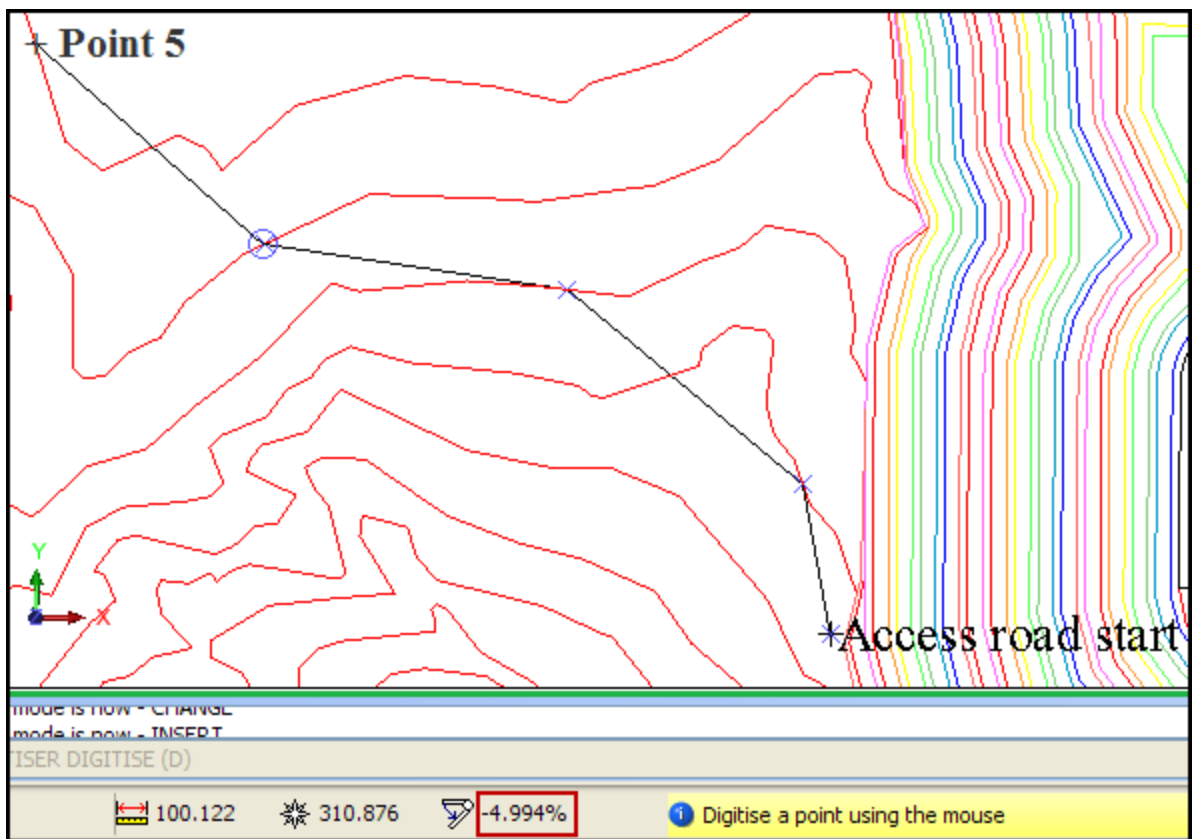
- Click on the contour line near Point 3, when the gradient is approximately -5%, as shown.



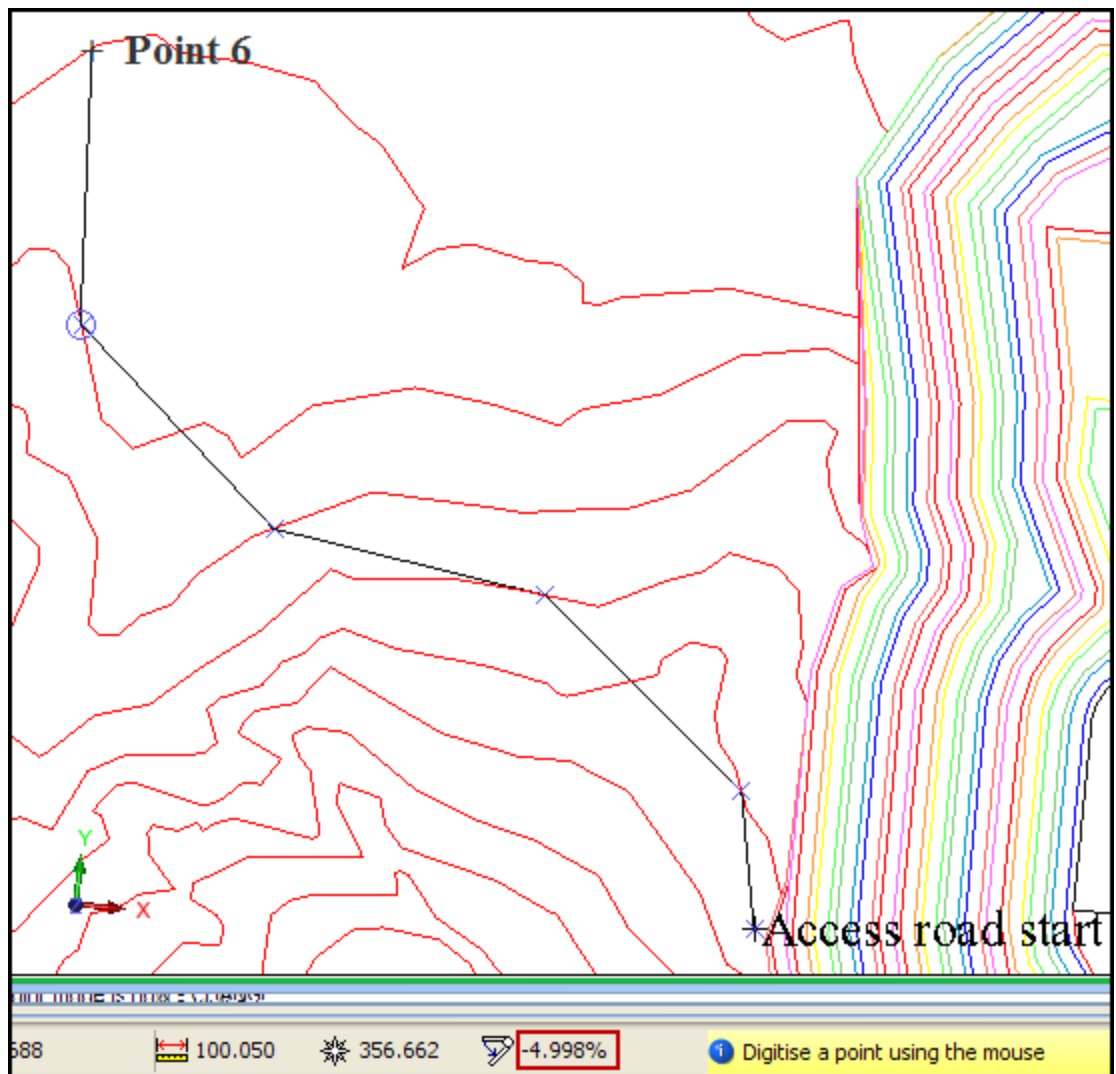
- Click on the next contour line near Point 4, when the gradient is approximately -5%, as shown.



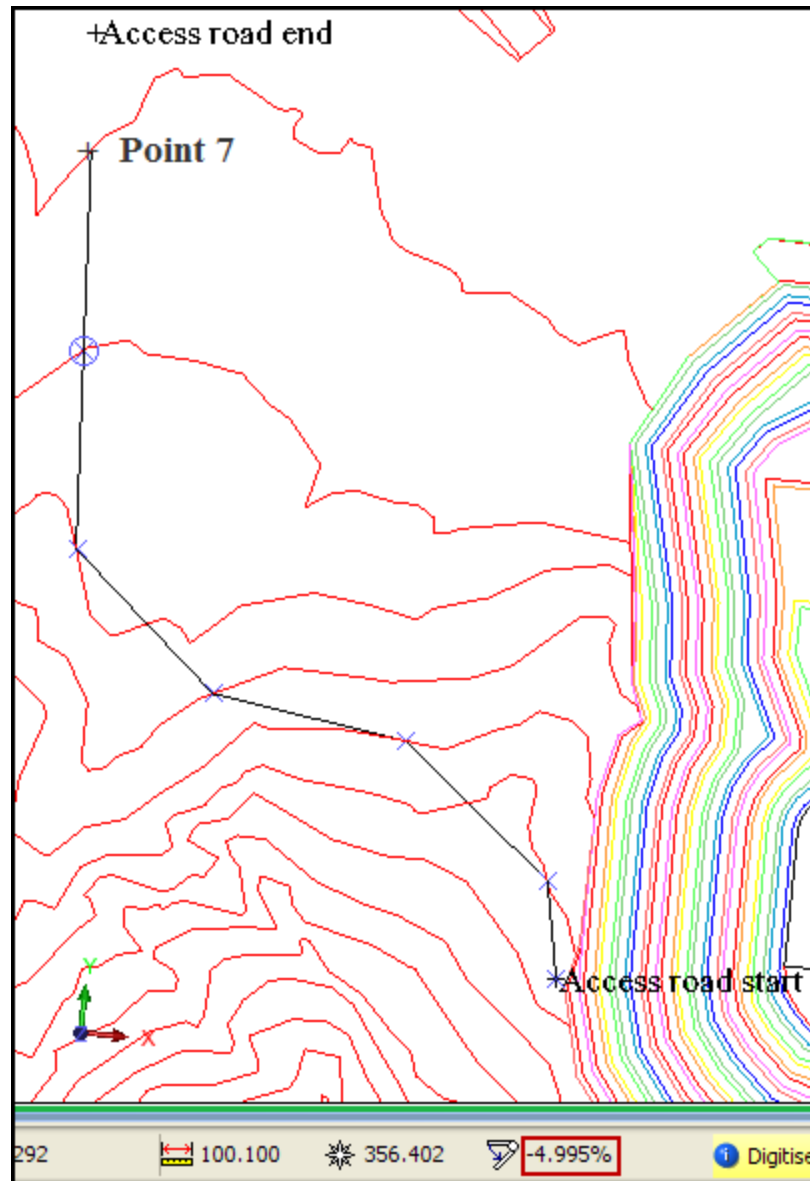
- Click on the next contour line near Point 5, when the gradient is approximately -5% as shown.



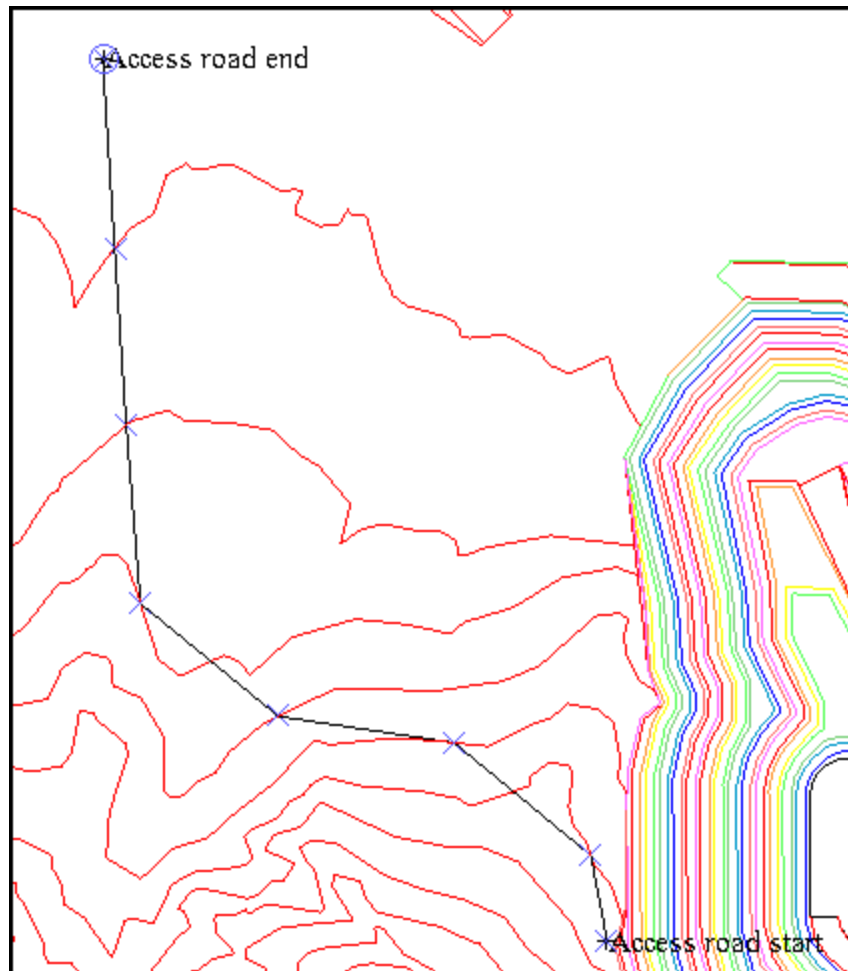
20. Click on the next contour line near Point 6, when the gradient is approximately -5% as shown.



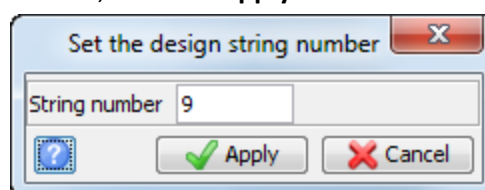
- Click on the next contour line near Point 7, when the gradient is approximately -5% as shown.



- Click the **Access road end** point, as shown.

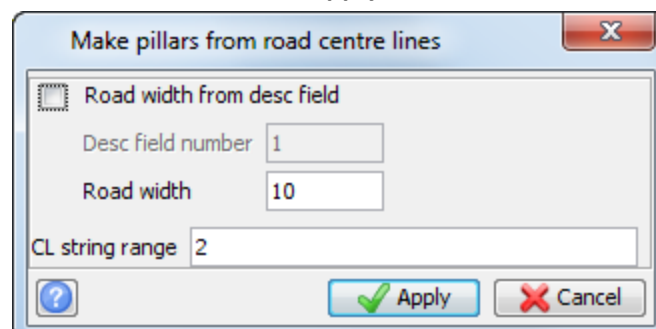


- Press ESC.
- Click the design string button **Str = 1** on the Status bar.
- Enter the information as shown, and click **Apply**.

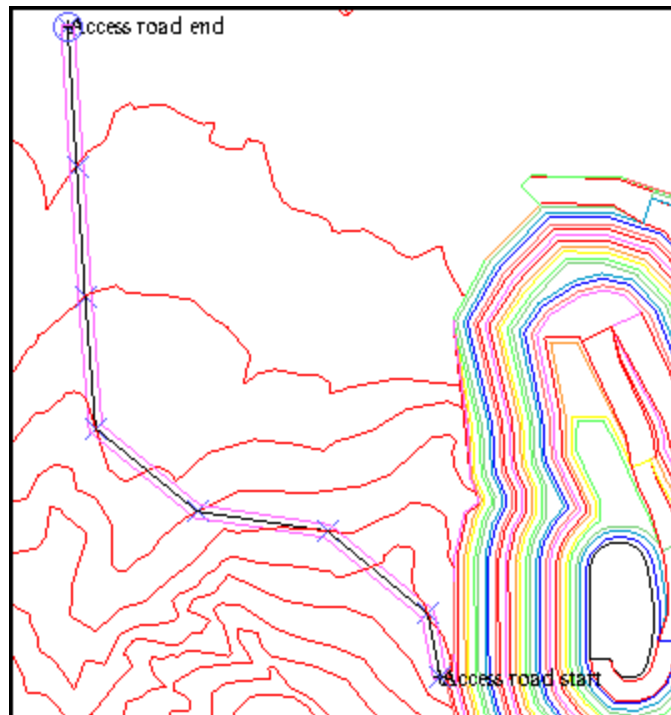



The design string number of 9 will be used for the road outline.

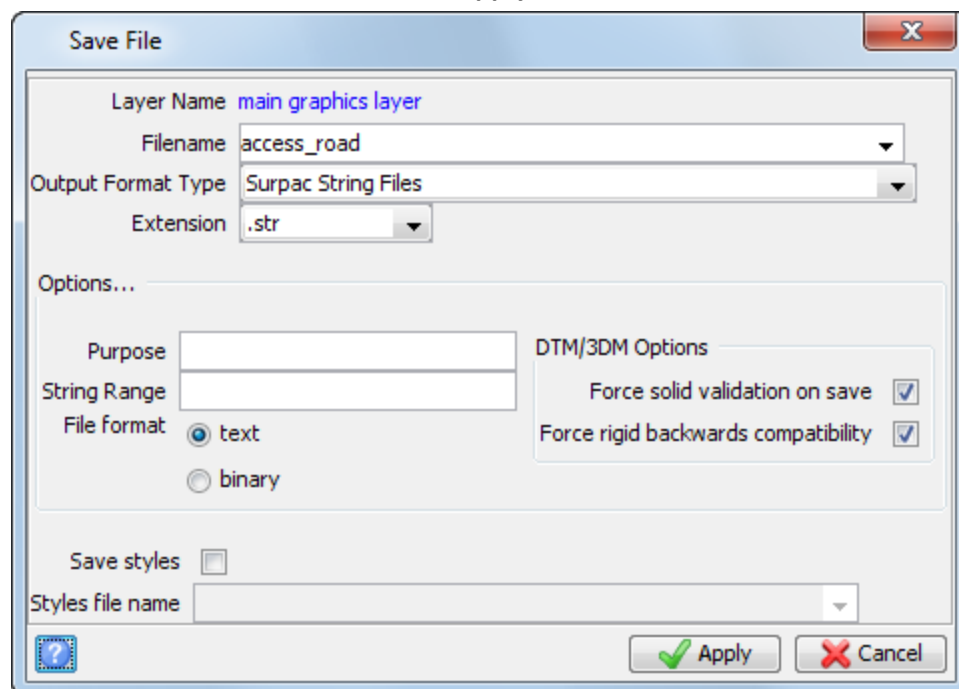
- Choose **Design > Underground tools > Room & pillar from centrelines**.
- Enter the information as shown, and click **Apply**.



The road outline is created, as shown.



28. Click **Save**  .
29. Enter the information as shown, and click **Apply**.

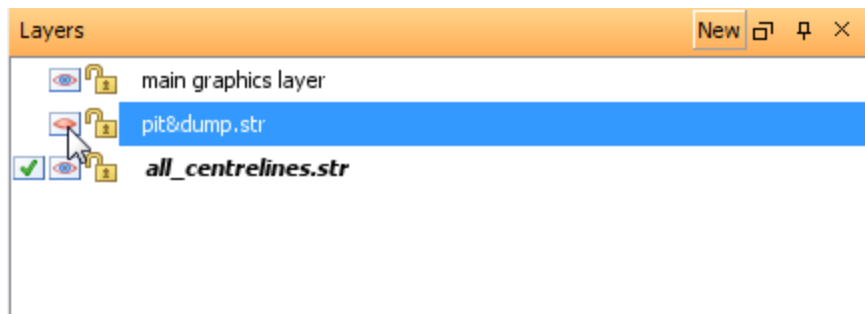


**Note:** To see all the steps performed in this section, run `1c_access_road.tcl`. You need to click **Apply** on any forms presented.

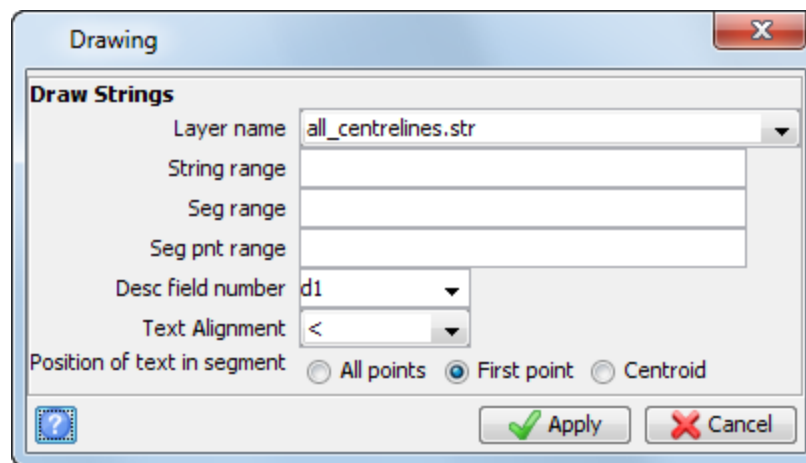
### Task: Create a variable width road outline

In this task, you will learn how to create a road outline of variable width from several centreline strings.

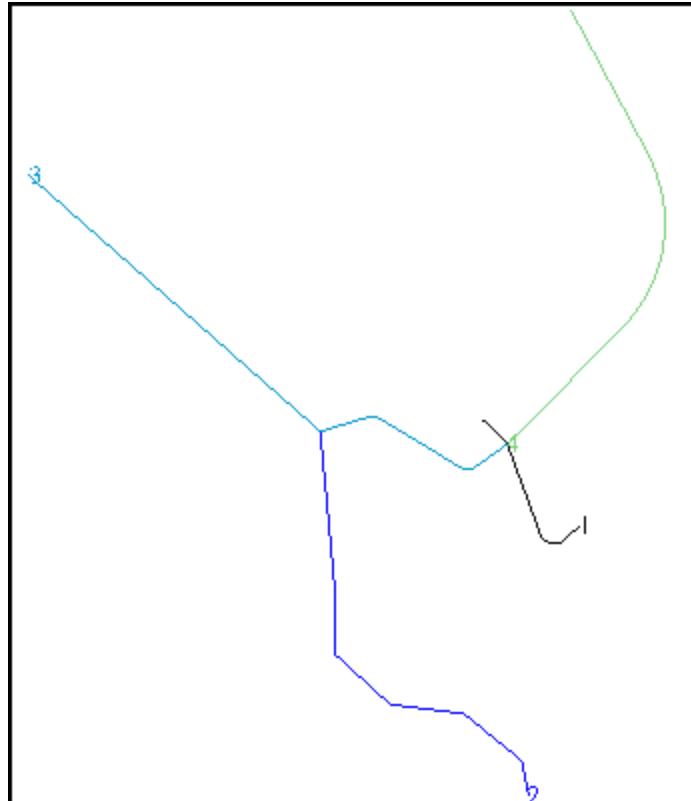
1. Click **Reset graphics** .
2. Open **pit&dump.str** in **Graphics**.
3. Open **all\_centrelines.str** in **Graphics**.
4. In the **Layers** pane, click the eye icon to hide **pit&dump.str**.



5. Choose **Display > Strings > With string numbers**.
6. Enter the information as shown, and click **Apply**.



The road centreline strings are displayed.



7. Choose **File tools > String maths**.
8. Enter the information as shown, and click **Apply**.

**String maths** ✕

Define the files to be processed


Location  ▼

ID range

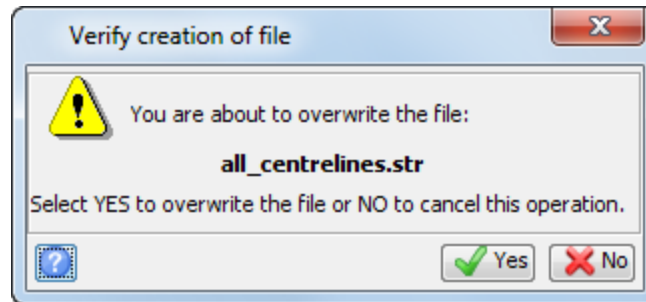
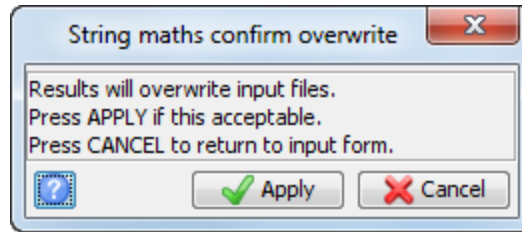
Define the files to be created

Location  ▼


	String range	Constraint	Field	=	Expression
1	1		d1	=	20
2	2		d1	=	10
3	3,4		d1	=	30
4				=	
5				=	
6				=	
7				=	
8				=	
9				=	
10				=	

 **Note:** The D1 field is set to the desired road width for each string or string range.

9. If prompted, click **Apply** to overwrite the file.

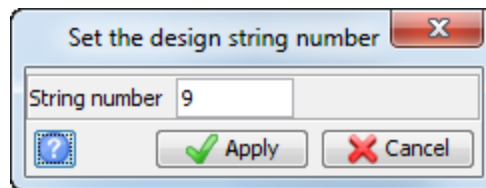


10. Open **all\_centrelines.str** in **Graphics**.

 **Note:** The output of the STR MATHS function is written to the file on disk. To have the information available for MAKE PILLARS, it must be re-opened in **Graphics**.

11. Click the design string button **Str = 1** on the status bar.

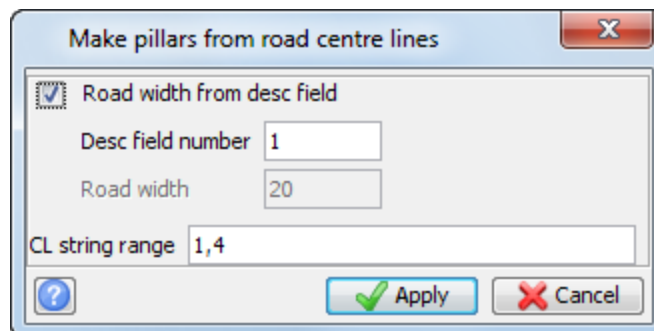
12. Enter the information as shown, and click **Apply**.



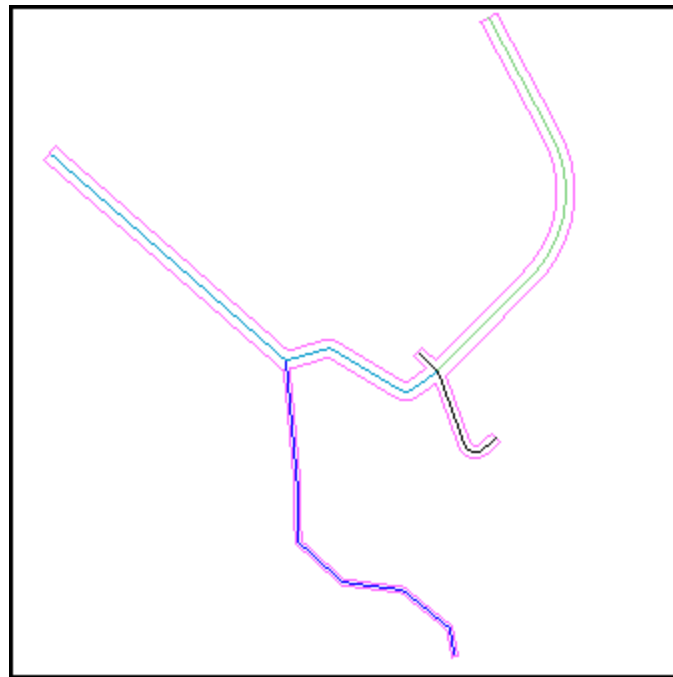
The design string number 9 will be used for the road outline.


13. Choose **Design > Underground tools > Room & pillar from centrelines**.

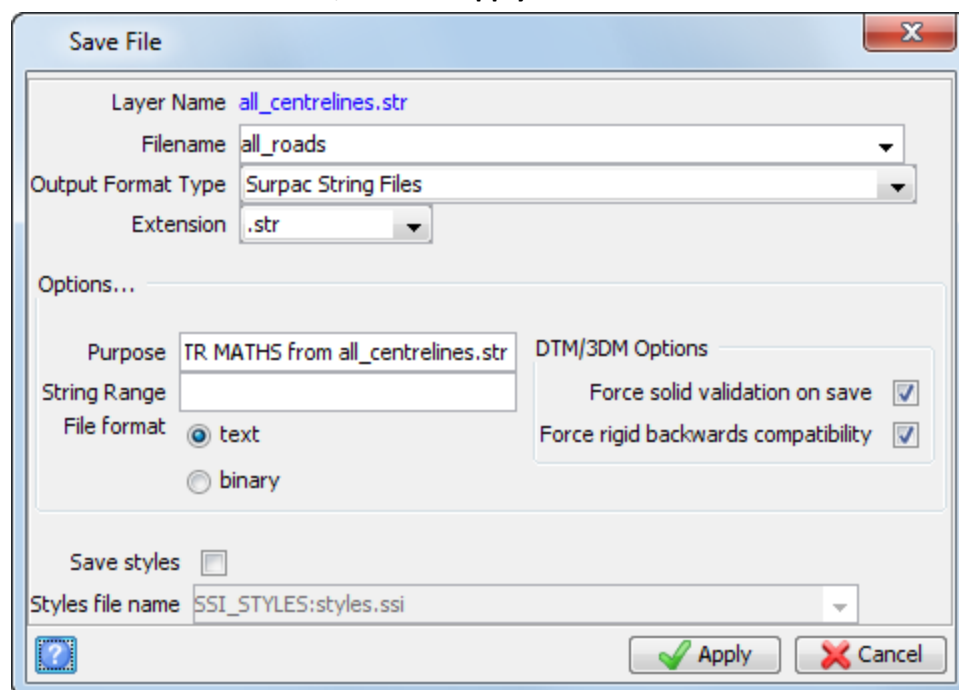
14. Enter the information as shown, and then click **Apply**.




The road outline for all centrelines is created at the width specified in the D1 field.



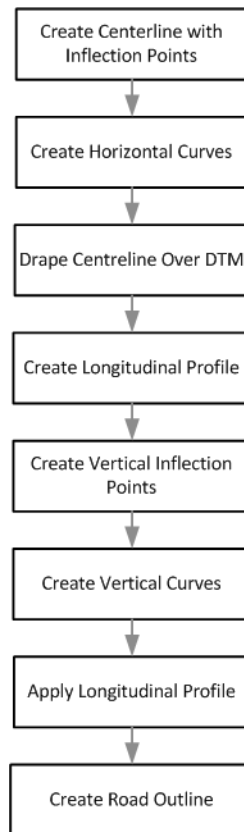
15. Click **Save** .
16. Enter the information as shown, and click **Apply**.



 **Note:** To see all the steps performed in this section, run `1d_variable_width_outline.tcl`. You will need to click **Apply** on any forms presented.


## Using the road design module

In this section, you will learn how to create a road design by using the Road Design Module. The workflow for this module is:



**Note:** This workflow demonstrates the steps in this tutorial. There are other ways to achieve a result.

### Task: View the data

1. Click **Reset graphics** .
2. Open **inflection\_points.str** in **Graphics**.
3. Choose **Display > Point > Numbers**.
4. Enter the information as shown, and click **Apply**.

**Drawing**

**Draw Segment point numbers**

Layer name: inflection\_points.str

String range: [ ]

Seg range: [ ]

Seg pnt range: [ ]

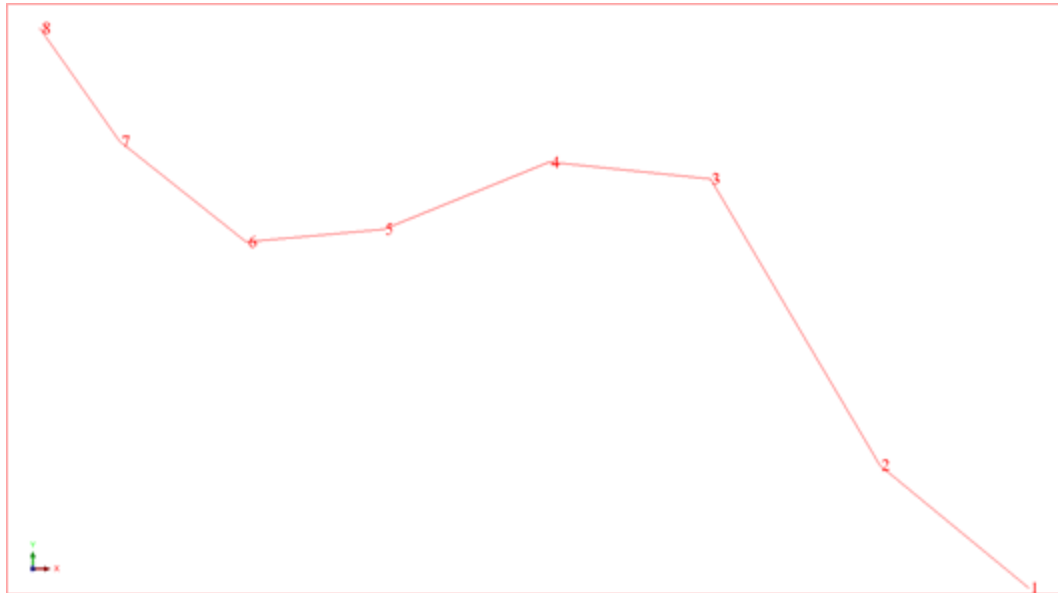
Desc field number: d1

Text Alignment: <

Position of text in segment: [ ]

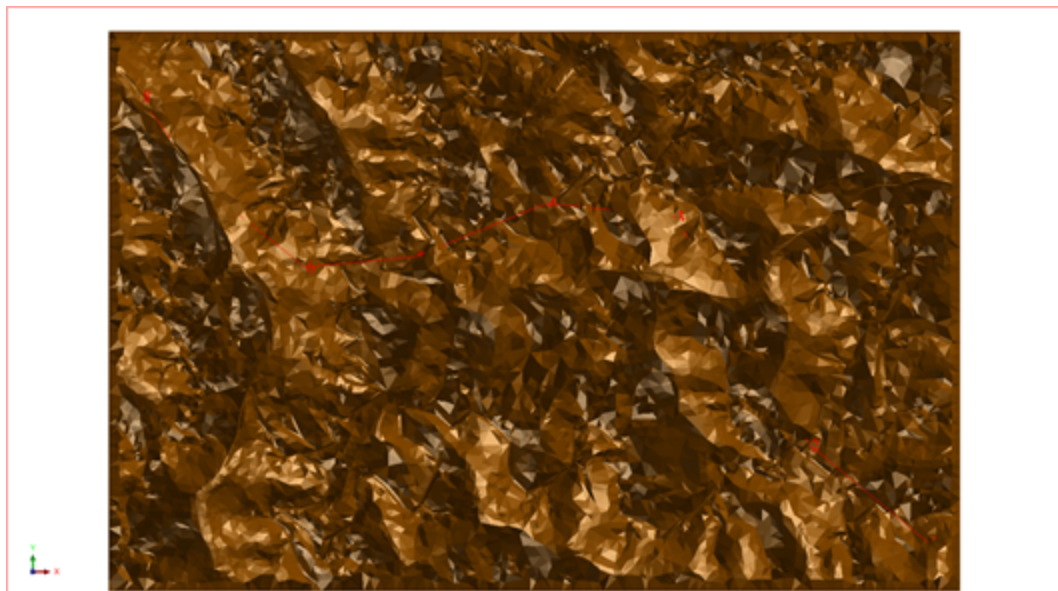
[?] [Apply] [Cancel]


In this example, you will create a road design between points 1 and 8, with horizontal curves at each inflection point (2, 3, 4, 5, 6, and 7).

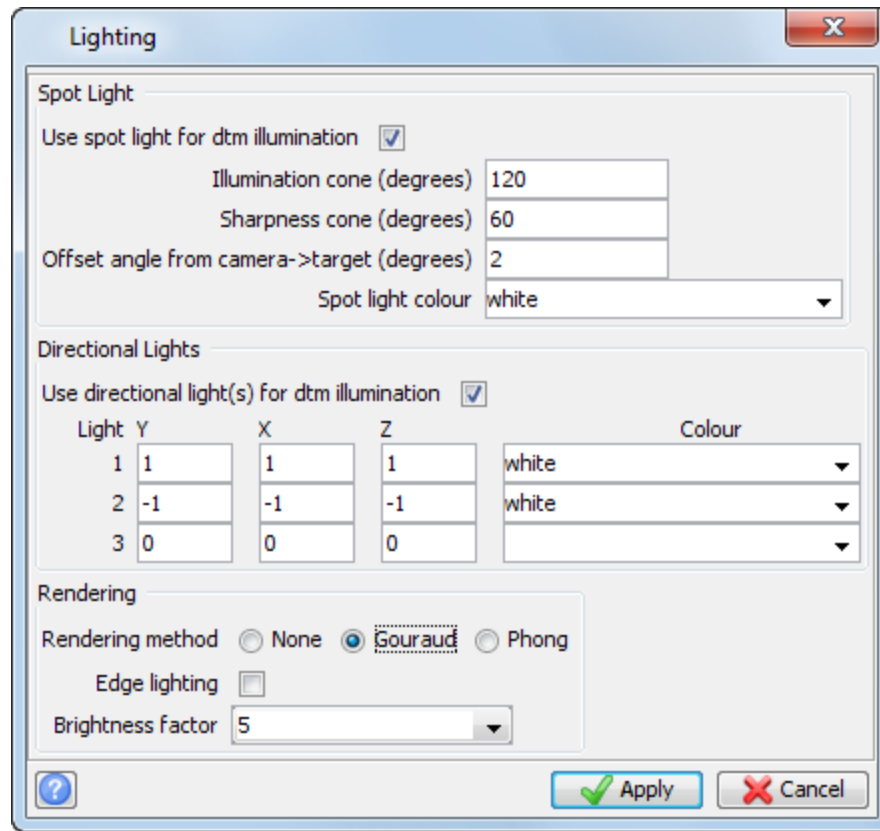


5. Open **topo.dtm**.

The DTM representing the surface topography is displayed.



6. Choose **View > Surface view options > Lighting options**, or click the  icon.
7. Enter the information as shown, and click **Apply**.



The image shows a 'Lighting' dialog box with the following settings:

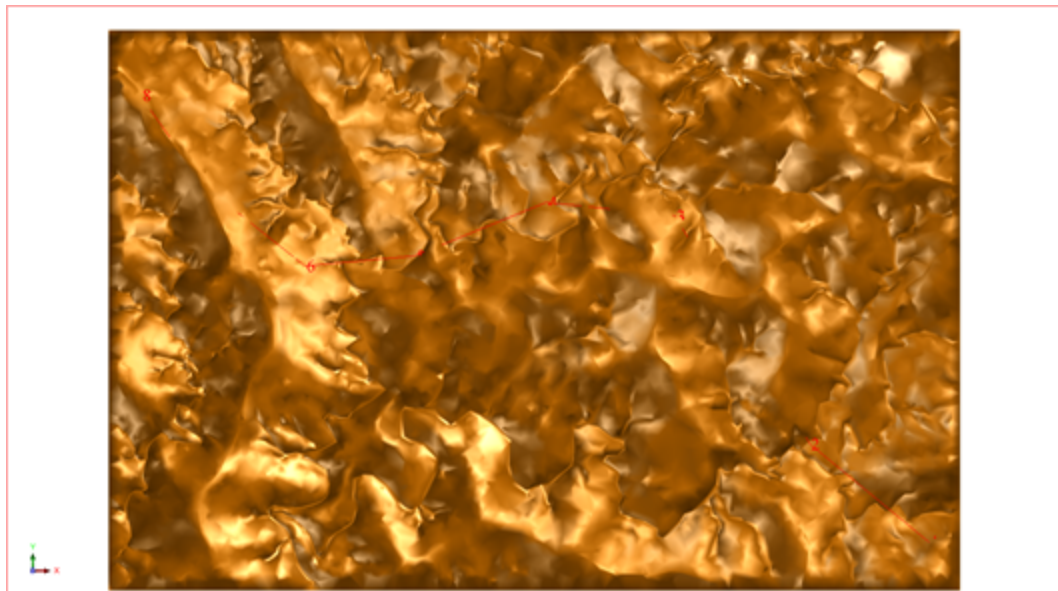
- Spot Light**
  - Use spot light for dtm illumination:
  - Illumination cone (degrees): 120
  - Sharpness cone (degrees): 60
  - Offset angle from camera->target (degrees): 2
  - Spot light colour: white
- Directional Lights**
  - Use directional light(s) for dtm illumination:
  - Table of light settings:

Light	Y	X	Z	Colour
1	1	1	1	white
2	-1	-1	-1	white
3	0	0	0	

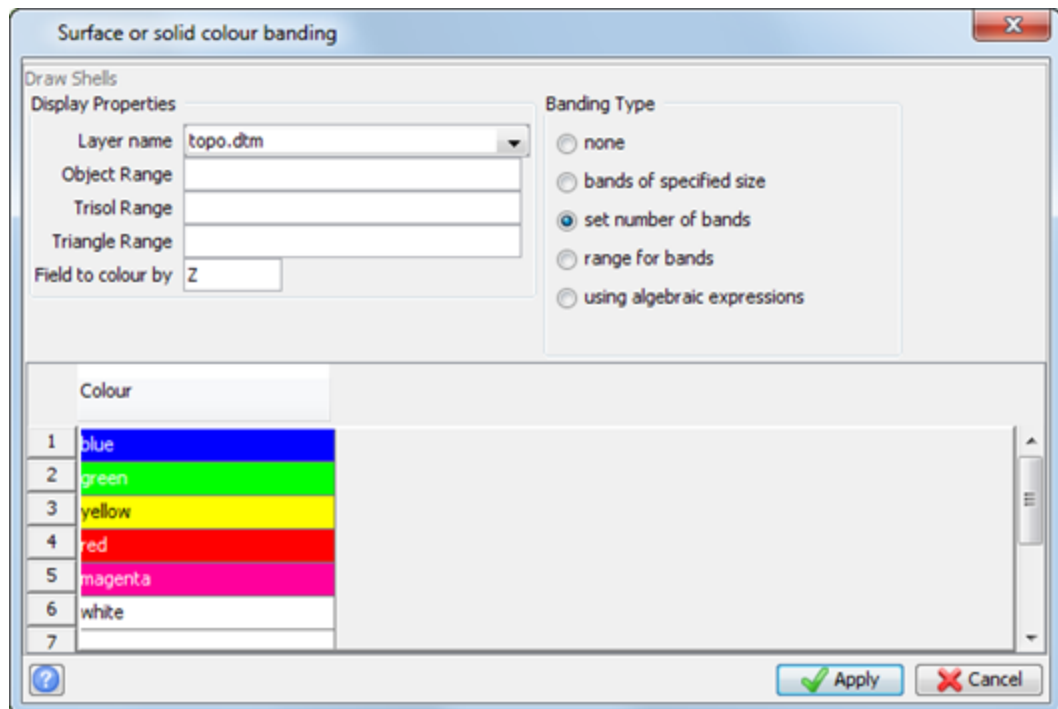
- Rendering**
  - Rendering method:  None,  Gouraud,  Phong
  - Edge lighting:
  - Brightness factor: 5

Buttons: ? (Help), Apply, Cancel

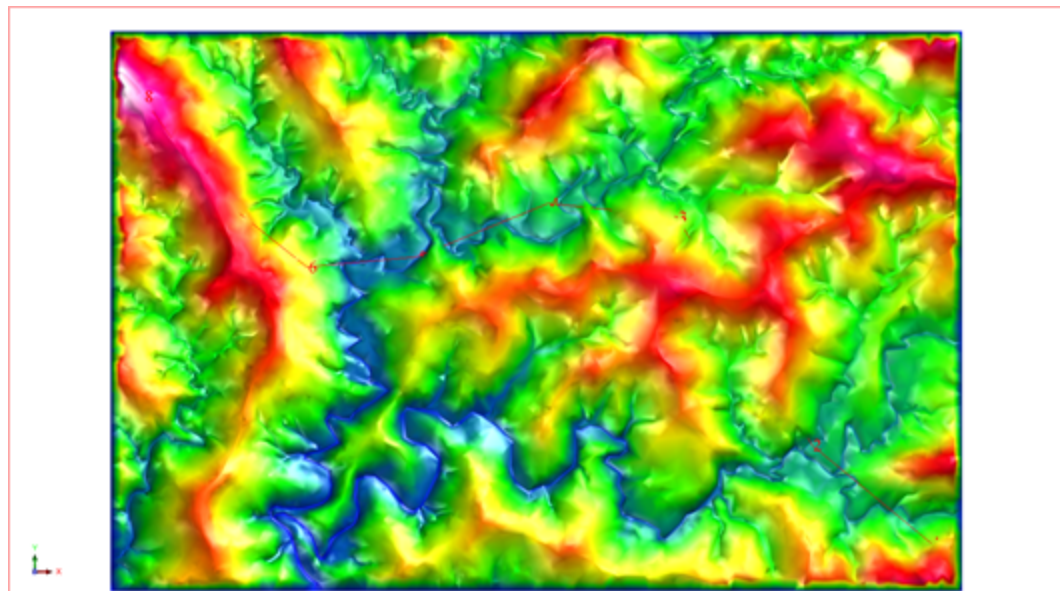
The Gouraud rendering smooths the surface.



8. Choose **Display > Surface or solid with colour banding**.
9. Enter the information as shown, and click **Apply**.




The lower elevations are coloured blue and green, and the higher elevations are magenta and white.

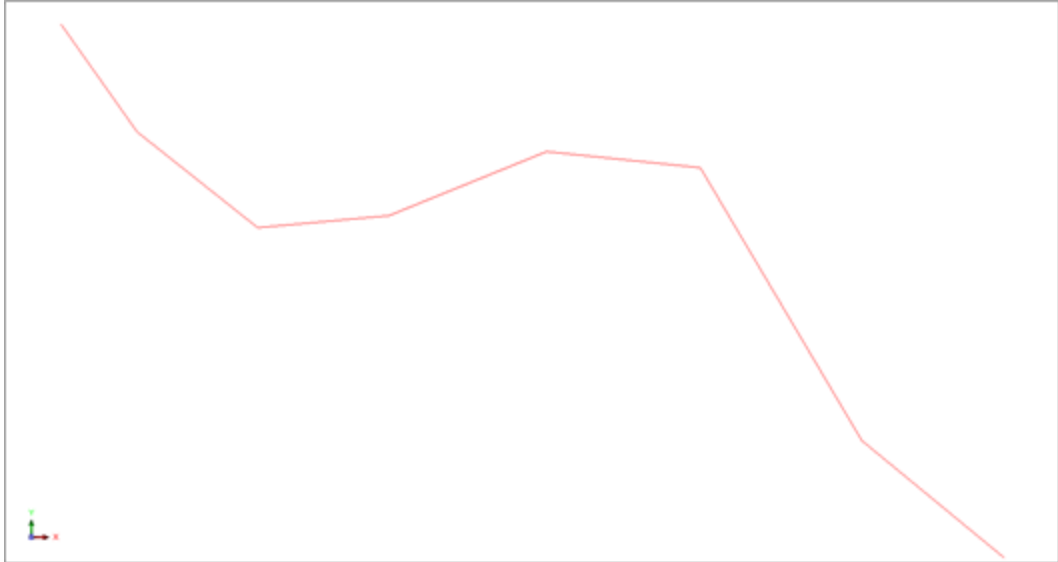


**Note:** To see all the steps performed in this section, run `2a_view_data.tcl`. You will need to click **Apply** on any forms presented.

### Task: Create horizontal curves

In this task, you will learn how to create horizontal curves from a string representing the start and end point of a road design, and one inflection point per horizontal curve. In this example, the inflection points, maximum vehicle velocity, and the radius for each curve are given. In practice, you would determine these values.

1. Click **Reset graphics** .
2. Open **inflection\_points.str** in **Graphics**.  
In this example, you will design horizontal curves at each of the inflection points in this string.



3. Choose **Road design > Design horizontal alignment**.
4. Click the string.
5. Enter the information as shown, and click **Calculate**.

**Design horizontal alignment**

Design segment

Output string: 2

Name:

Initial Chainage: 0.00

Chainage interval: 25.00

Calculate road parameters

Vehicle velocity: 50.00

Road design details

	Radius	Fixed	Transition length	Superelevation	Status
1	800.00	<input type="checkbox"/>	0.00	0.00	Valid
2	300.00	<input type="checkbox"/>	0.00	0.00	Valid
3	300.00	<input type="checkbox"/>	0.00	0.00	Valid
4	300.00	<input type="checkbox"/>	0.00	0.00	Valid
5	400.00	<input type="checkbox"/>	0.00	0.00	Valid
6	500.00	<input type="checkbox"/>	0.00	0.00	Valid

A new string is created in the current layer with the output string number of 2.

The name is optional and can be left blank. You can choose to enter a name if you want to create a map with this information.

"Chainage" values are the cumulative two-dimensional distances at each point along the design, and begin with the "Initial Chainage" value.

Points are created at the start and end of each simple and transition curve, and at the chainage interval of 25 meters along the curves.

The vehicle velocity is in kilometers per hour.

The radius of each curve is in meters. You must enter the radius for each curve to perform the calculation.

When you have clicked the **Calculate** button, transition lengths and superelevation values are calculated for each curve which is not nominated as "Fixed". In this example, all curves contain a transition curve.

- After the transition and superelevation values have been calculated, click **Apply**.

**Design horizontal alignment**

Design segment

Output string: 2

Name:

Initial Chainage: 0.00

Chainage interval: 25.00

Calculate road parameters

Vehicle velocity: 50.00

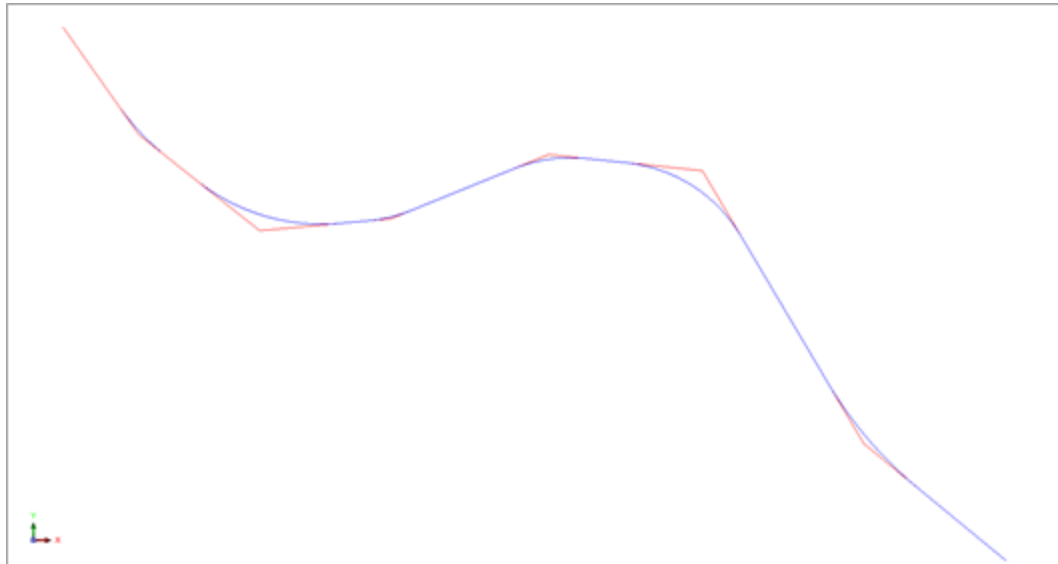
**Calculate**


Road design details


	Radius	Fixed	Transition length	Superelevation	Status
1	800.00	<input type="checkbox"/>	11.17	0.01	Valid
2	300.00	<input type="checkbox"/>	29.79	0.03	Valid
3	300.00	<input type="checkbox"/>	29.79	0.03	Valid
4	300.00	<input type="checkbox"/>	29.79	0.03	Valid
5	400.00	<input type="checkbox"/>	22.34	0.02	Valid
6	500.00	<input type="checkbox"/>	17.00	0.02	Valid

**Apply** **Cancel**

The horizontal curves are created in string 2, as displayed.



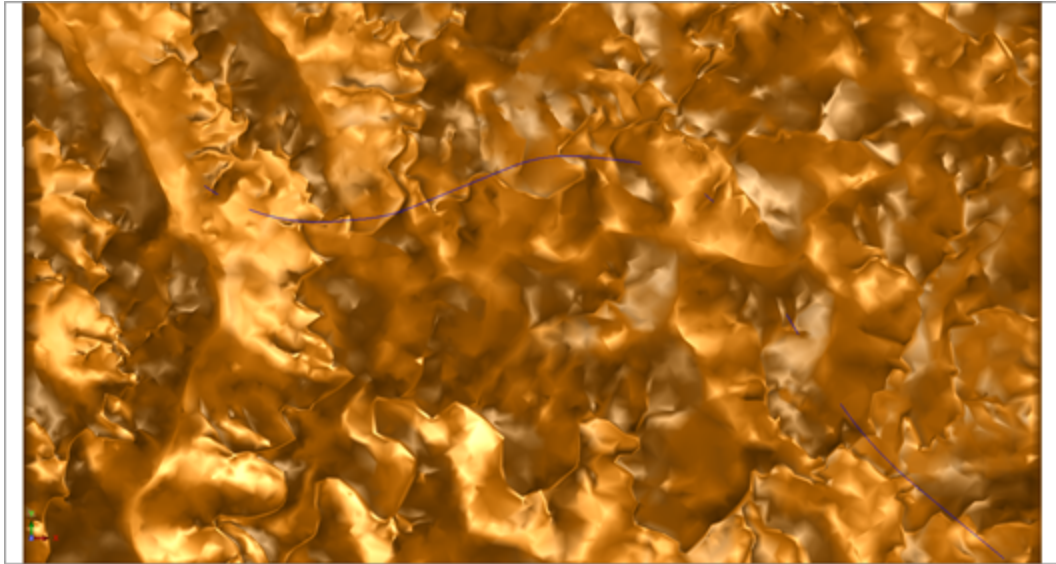
7. Click **Save** .
8. Enter the information as shown, and click **Apply**.

 **Note:** To see all the steps performed in this section, run **2b\_horizontal\_design.tcl**. You will need to click **Apply** on any forms presented.

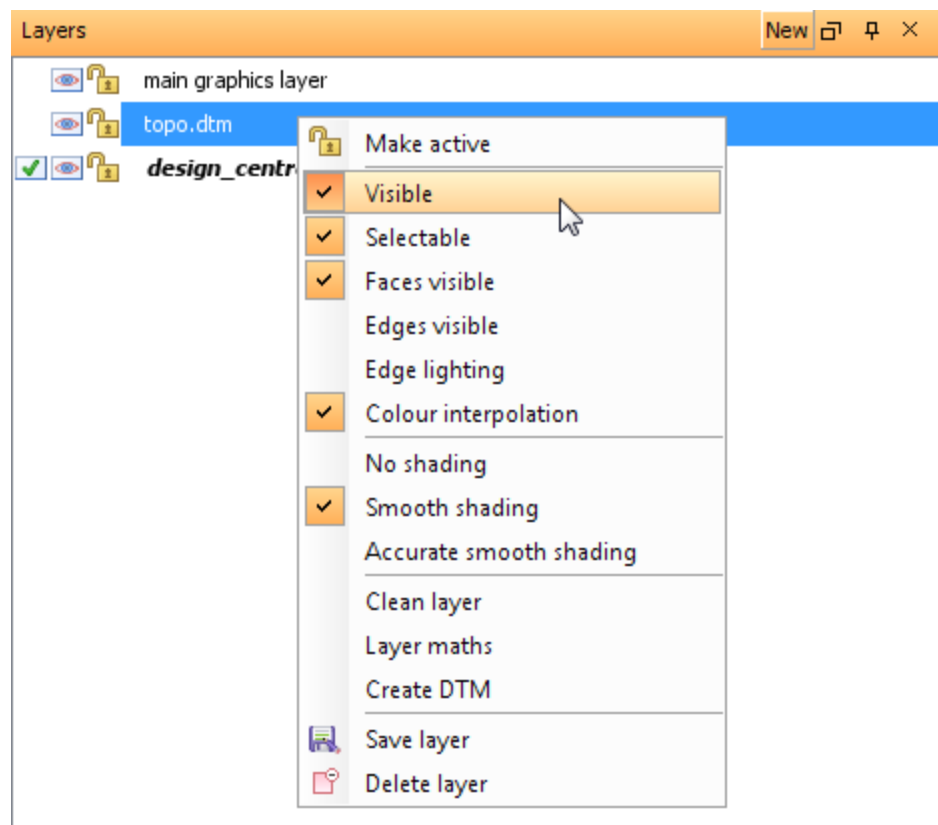
### Task: Drape centreline over DTM

1. Click **Reset graphics** .
2. Open **topo.dtm** in **Graphics**.

3. Open **design\_centreline.str**.  
The string and DTM are displayed.



4. In the **Layers** pane, right-click **topo.dtm**.



5. Click **Visible** to hide the DTM.
6. Choose **Road design > Drape segment over DTM**.
7. Click the string.

8. Enter the information as shown, and click **Apply**.

Segments over DTM

DTM layer name: topo.dtm

Object ID: 1

Trisolation ID: 1

Interpolate new points

Apply Cancel

9. Choose **Edit > String > Renumber**.
10. Click the string.
11. Enter the information as shown, and click **Apply**.


Renumber a string

Layer name: design\_centreline.str

Renumber string: 2

to string: 3

Apply Cancel

12. Press ESC.
13. In the **Layers** pane, right-click **topo.dtm**, and click **Visible** to display the DTM.  
 **Note:** You need to rotate the data in **Graphics** to view the string draped over the DTM.
14. Click **Save** .
15. Enter the information as shown, and click **Apply**.

Save File

Layer Name: design\_centreline.str

Filename: design\_centreline\_draped

Output Format Type: Surpac String Files

Extension: .str

Options...

Purpose:

String Range:

File format:  text  binary

DTM/3DM Options

Force solid validation on save

Force rigid backwards compatibility

Save styles

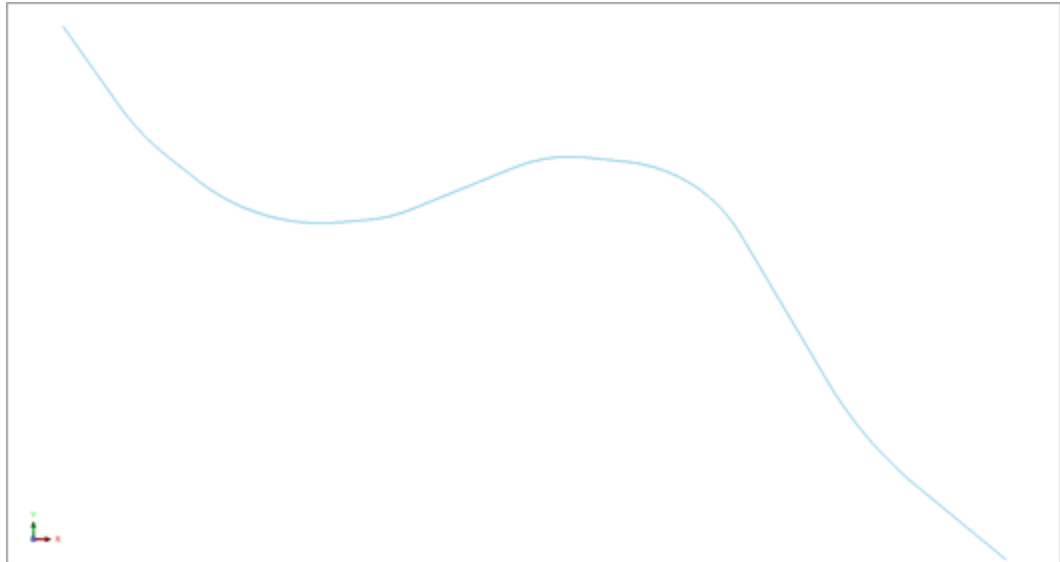
Styles file name: SSI\_STYLES:styles.ssi

Apply Cancel

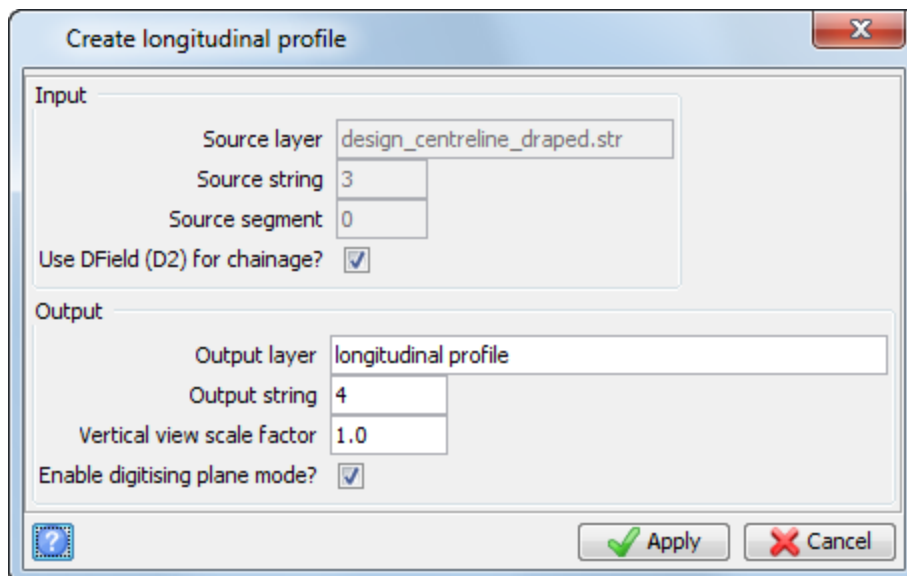
**Note:** To see all the steps performed in this section, run **2c\_design\_centreline\_draped.tcl**. You need to click **Apply** on any forms presented.

## Task: Create longitudinal profile

1. Click **Reset graphics** .
2. Open **design\_centrelines\_draped.str** in **Graphics**.  
The draped string is displayed.

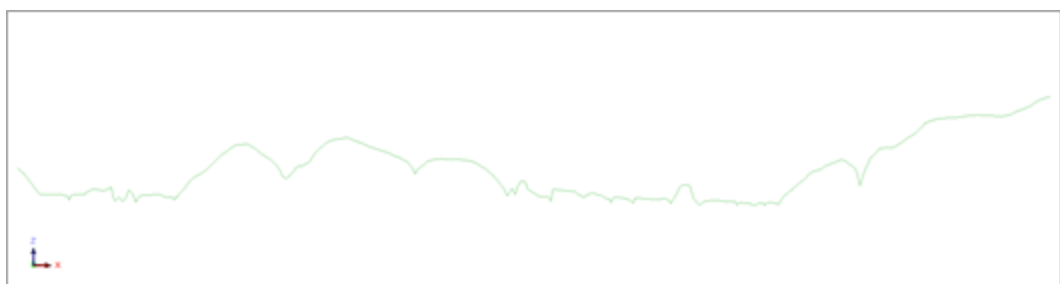



3. Choose **Road design > Create longitudinal profile**.
4. Click the string.
5. Enter the information as shown, and click **Apply**.




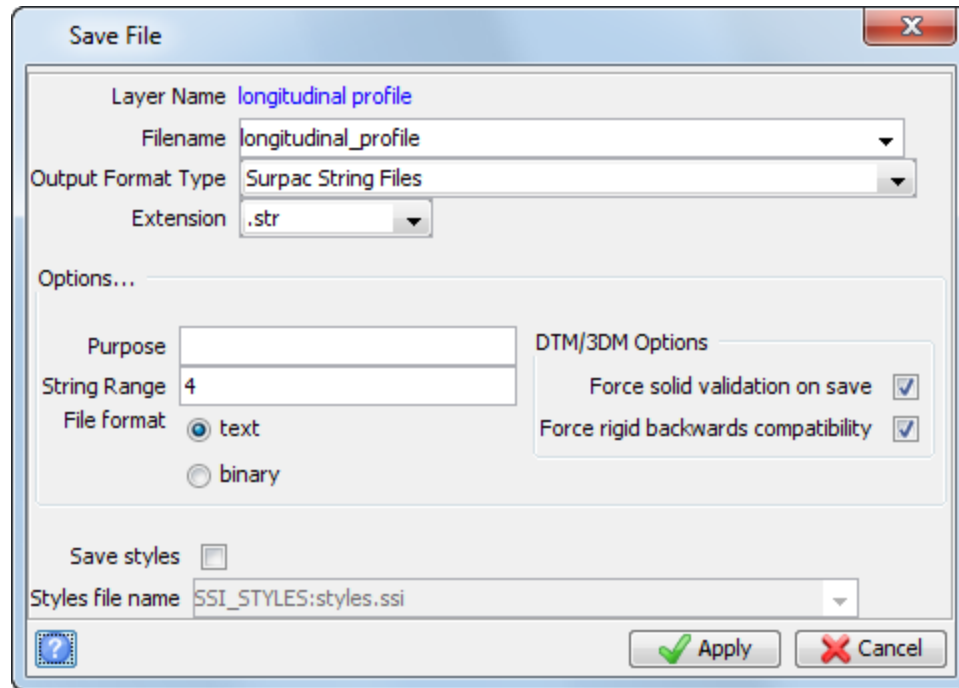
Create longitudinal profile	
<b>Input</b>	
Source layer	design_centrelines_draped.str
Source string	3
Source segment	0
Use DField (D2) for chainage?	<input checked="" type="checkbox"/>
<b>Output</b>	
Output layer	longitudinal profile
Output string	4
Vertical view scale factor	1.0
Enable digitising plane mode?	<input checked="" type="checkbox"/>
Apply Cancel	

The longitudinal profile is displayed in the lower viewport.






 **Note:** You need to keep string 4 displayed in **Graphics** to perform the next task.


6. Click **Save** .
7. Enter the information as shown, and click **Apply**.




The 'Save File' dialog box is shown with the following settings:


- Layer Name: longitudinal profile
- Filename: longitudinal\_profile
- Output Format Type: Surpac String Files
- Extension: .str
- Options...:
  - Purpose: (empty text box)
  - String Range: 4
  - File format:  text,  binary
  - DTM/3DM Options:
    - Force solid validation on save:
    - Force rigid backwards compatibility:
- Save styles:
- Styles file name: SSI\_STYLES:styles.ssi

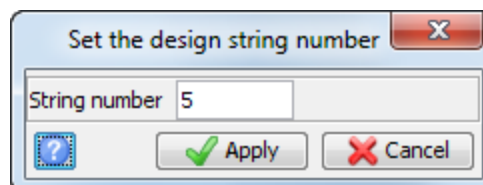
Buttons:   

 **Note:** To see all the steps performed in this section, run `2d_create_longitudinal_profile.tcl`. You need to click **Apply** on any forms presented.

### Task: Create vertical inflection points




 **Note:** You need the data displayed from the previous task. If you do not have the data displayed, run macro `2d_create_longitudinal_profile.tcl`.

1. Click the lower viewport.
2. Click the **Design string**  button in the Status bar.
3. Enter the information as shown, and click **Apply**.

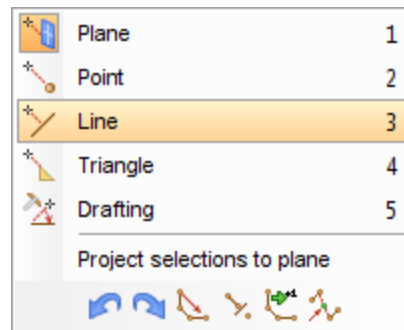


The 'Set the design string number' dialog box is shown with the following settings:

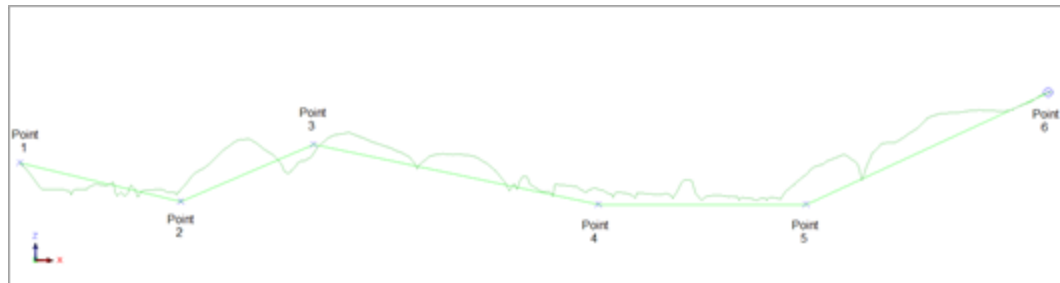
- String number: 5

Buttons:   

4. Choose **Create > Digitise > New point**.
5. Right-click in **Graphics** and choose **Point**, for the snap mode.



- Click the string at Point 1.  
The numbered string is displayed.



- Right-click in **Graphics**, and choose **Plane**.
- Click the string at Points 2 to 5.
- Right-click in **Graphics**, and choose **Point**.
- Click the string at Point 6.
- Press ESC.
  - Note:** You need to keep string 5 displayed in **Graphics** to perform the next task.
- Click **Save** .
- Enter the information as shown, and click **Apply**.

**Save File** X

Layer Name longitudinal profile

Filename

Output Format Type Surpac String Files


Extension .str

Options...


Purpose <input type="text"/> String Range <input type="text" value="5"/> File format <input checked="" type="radio"/> text <input type="radio"/> binary	<b>DTM/3DM Options</b> Force solid validation on save <input checked="" type="checkbox"/> Force rigid backwards compatibility <input checked="" type="checkbox"/>
--	---

Save styles

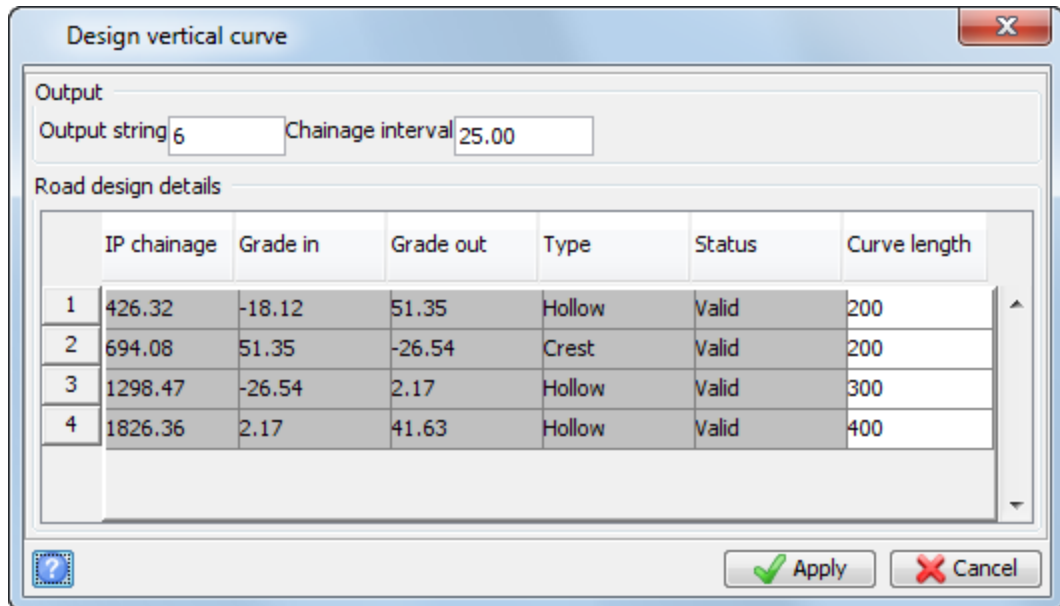
Styles file name SSI\_STYLES:styles.ssi

 **Note:** To see all the steps performed in this section, run `2e_create_vertical_inflection_points.tcl`. You need to click **Apply** on any forms presented.

### Task: Create vertical curves

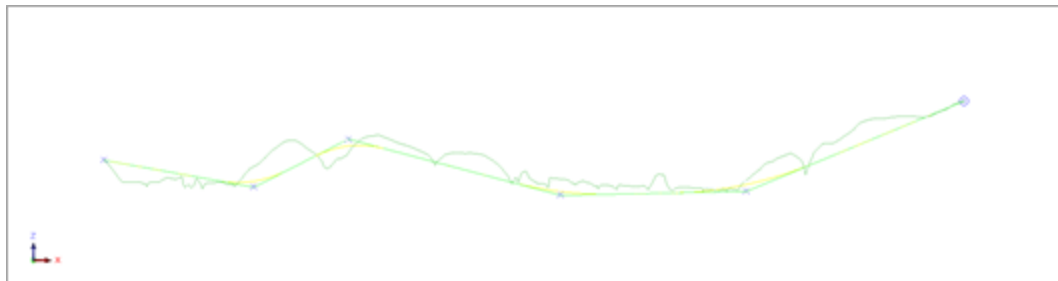
 **Note:** You need the data displayed from the previous task. If you do not have the data displayed, run macro `2e_create_vertical_inflection_points.tcl`.

1. Click the lower viewport.
2. Choose **Road design > Design vertical alignment**.
3. Click string 5.
4. Enter the information as shown, and click **Apply**.



	IP chainage	Grade in	Grade out	Type	Status	Curve length
1	426.32	-18.12	51.35	Hollow	Valid	200
2	694.08	51.35	-26.54	Crest	Valid	200
3	1298.47	-26.54	2.17	Hollow	Valid	300
4	1826.36	2.17	41.63	Hollow	Valid	400

The vertical curves are displayed.



 **Note:** You need to keep string 6 displayed in **Graphics** to perform the next task.

5. Click Save .

6. Enter the information as shown, and click **Apply**.

**Note:** To see all the steps performed in this section, run `2f_create_vertical_curves.tcl`. You need to click **Apply** on any forms presented.


#### Task: Apply longitudinal profile

**Note:** You need the data displayed from the previous task. If you do not have the data displayed, run macro `2f_create_vertical_curves.tcl`.


1. Choose **Road design > Apply longitudinal profile**.
2. Click the lower viewport.
3. Press F1 to suspend the function.
4. Zoom in on a curve.
5. Press ESC to continue.
6. Click string 6.
7. Click in the upper viewport.
8. Click string 3.
9. Enter the information as shown, and click **Apply**.

10. Choose **Edit > Segment > Renumber**.
11. Click string 3.
12. Enter the information as shown, and click **Apply**.


Layer name	design_centrelines_draped.str	
Renumber string	3	
segment	1	
to string	7	

13. Click Save .
14. Enter the information as shown, and click **Apply**.

Layer Name	design_centrelines_draped.str	
Filename	final_centrelines_design	
Output Format Type	Surpac String Files	
Extension	.str	
Options...		
Purpose		DTM/3D Options
String Range	7	Force solid validation on save <input checked="" type="checkbox"/>
File format	<input checked="" type="radio"/> text	Force rigid backwards compatibility <input checked="" type="checkbox"/>
	<input type="radio"/> binary	
Save styles	<input type="checkbox"/>	
Styles file name	SSI_STYLES:styles.ssi	

 **Note:** To see all the steps performed in this section, run **2g\_apply\_longitudinal\_outline.tcl**. You need to click **Apply** on any forms presented.

### Task: Create road outline

1. Click **Reset graphics** .
2. Open **final\_centrelines\_design.str** in **Graphics**.
3. Choose **Road design > Create road outline**.
4. Click the string.
5. Enter the information as shown, and click **Apply**.

Create a road outline

Output

Output string 8

Join the start of the outline?

Join the end of the outline?

Road width

Left road width 5

Right road width 5

Description Fields

Use DField (D2) for chainage?

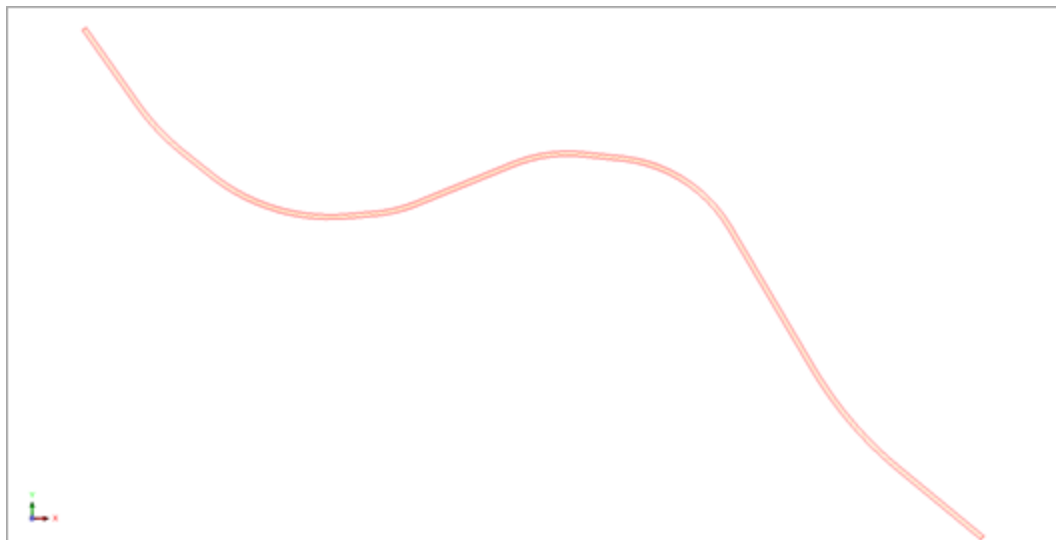
Use DField (D4) for superelevation?

Use DField (D6) for the left width?

Use DField (D7) for the right width?

? Apply Cancel

The road outline is displayed.



6. Choose **Edit > String > Clean**.

7. Enter the information as shown, and click **Apply**.

Clean string

Function

Closure

Cross-overs

Duplicate Point

Duplicate Segment

Minimum Area

Minimum Points

Spikes

Action  mark  remove  warn

Target  layer  string  segment

Minimum trap distance 0

Maximum trap distance 1

Marker colour red

Measure distances and angles in  2D space  3D space

Apply Cancel

8. Click the string.

9. Choose **Edit > String > Clean**.
10. Enter the information as shown, and click **Apply**.

Clean string

Function

Closure

Cross-overs

Duplicate Point

Duplicate Segment

Minimum Area

Minimum Points

Spikes

Action  mark  remove  warn

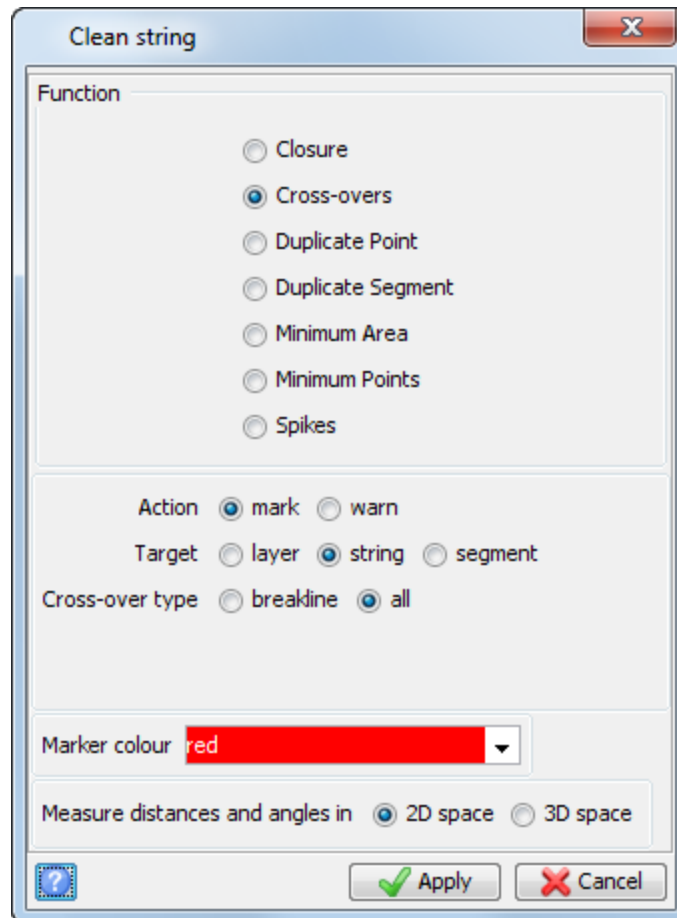
Trap angle  degrees


Target **segment**

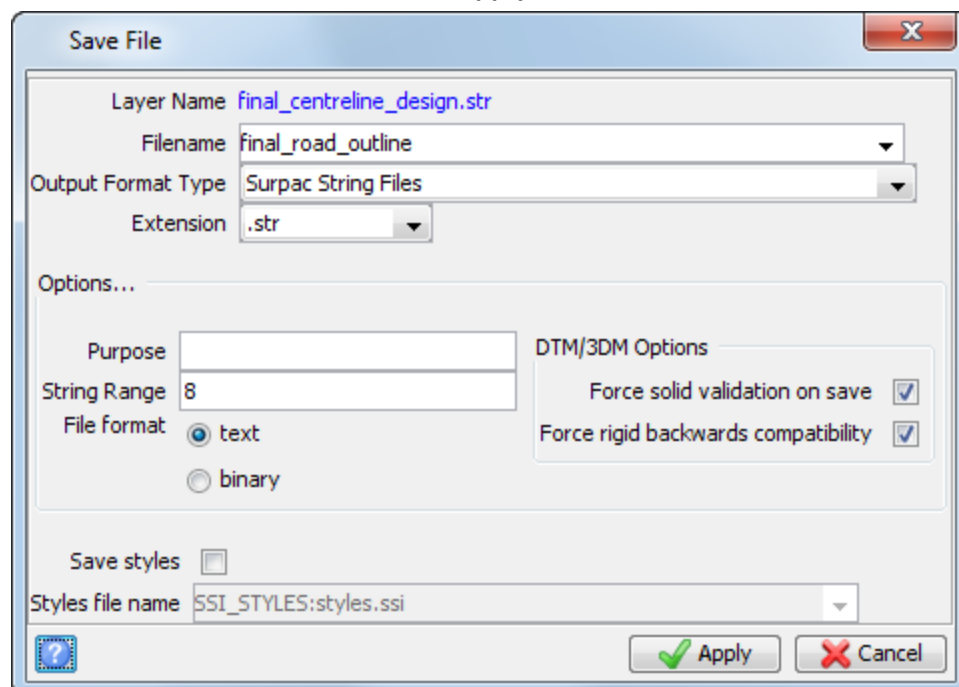
Marker colour


Measure distances and angles in  2D space  3D space

11. Click the string.
12. Choose **Edit > String > Clean**.
13. Enter the information as shown, and click **Apply**



14. Click the string.
15. Click **Save** .
16. Enter the information as shown, and click **Apply**.

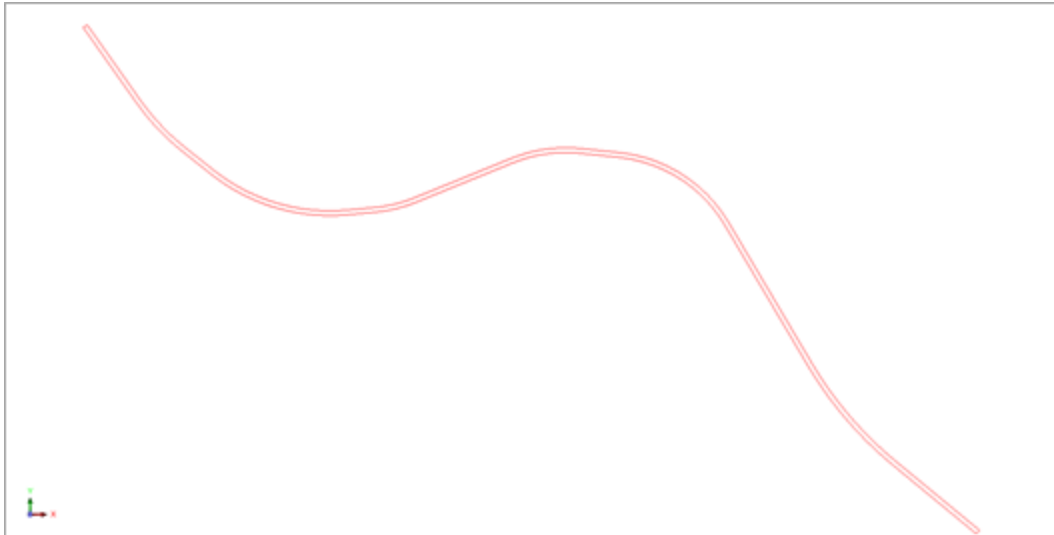


 **Note:** To see all the steps performed in this section, run **2h\_create\_road\_outline.tcl**. You need to click **Apply** on any forms presented.

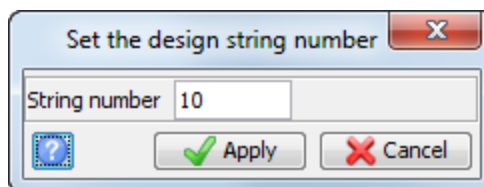
## Calculating road design volumes

### Task: Calculate road cut

1. Click **Reset graphics** .
2. Open **final\_road\_outline.str** in **Graphics**.  
The road outline string is displayed.



3. Click the Design string **Str = 1** button on the Status bar.
4. Enter the information as shown, and click **Apply**.

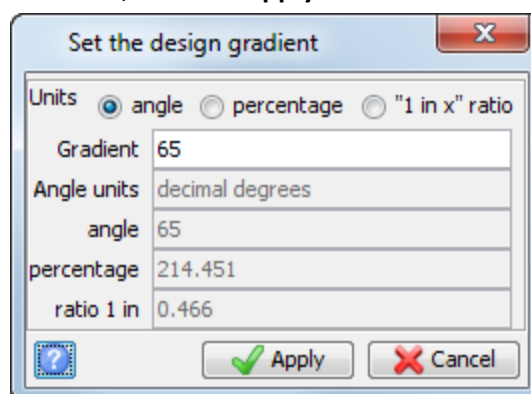


Set the design string number

String number 10

Apply Cancel

5. Choose **Pit design > Set slope gradient**.
6. Enter the information as shown, and click **Apply**.



Set the design gradient

Units  angle  percentage  "1 in x" ratio

Gradient 65

Angle units decimal degrees

angle 65

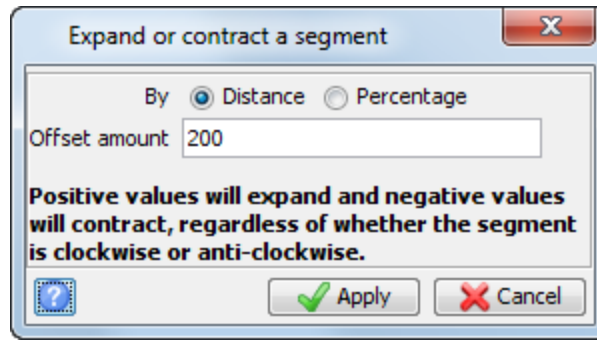
percentage 214.451

ratio 1 in 0.466

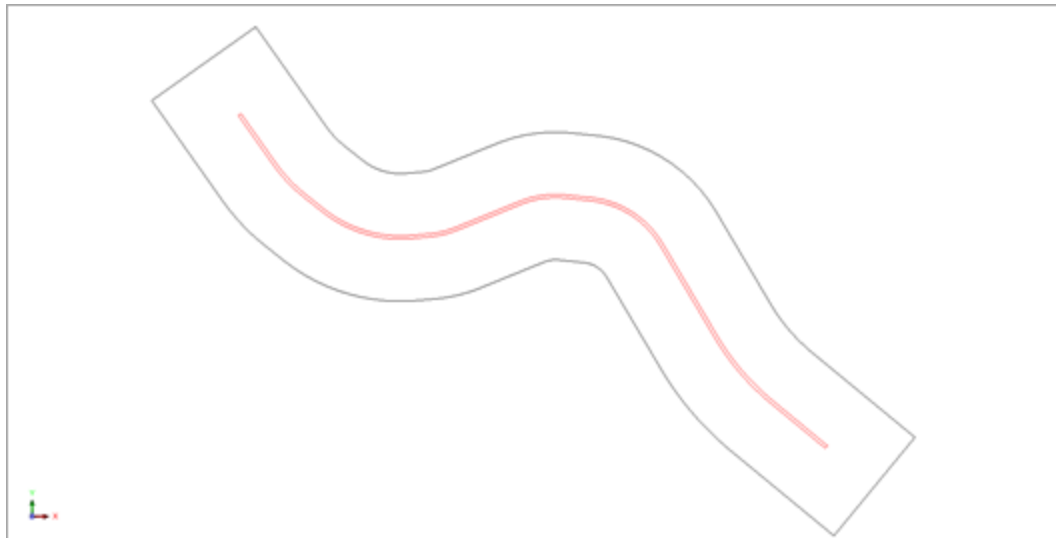
Apply Cancel

7. Choose **Edit > Segment > Expand/Contract**.
8. Click the road outline in **Graphics**.

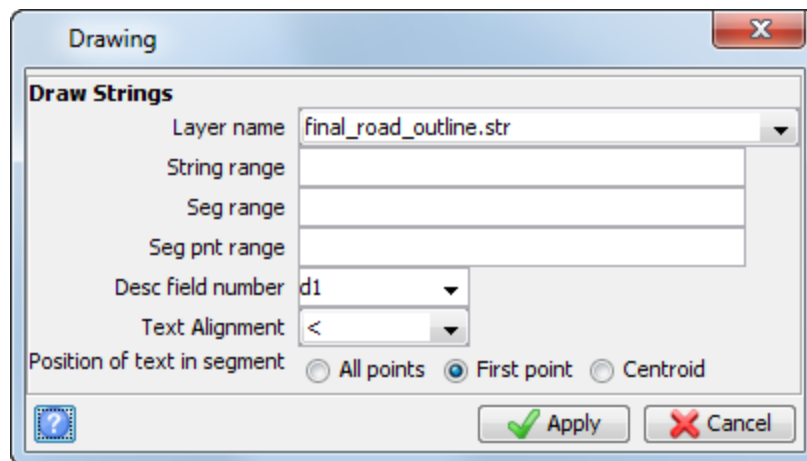
9. Enter the information as shown, and click **Apply**.



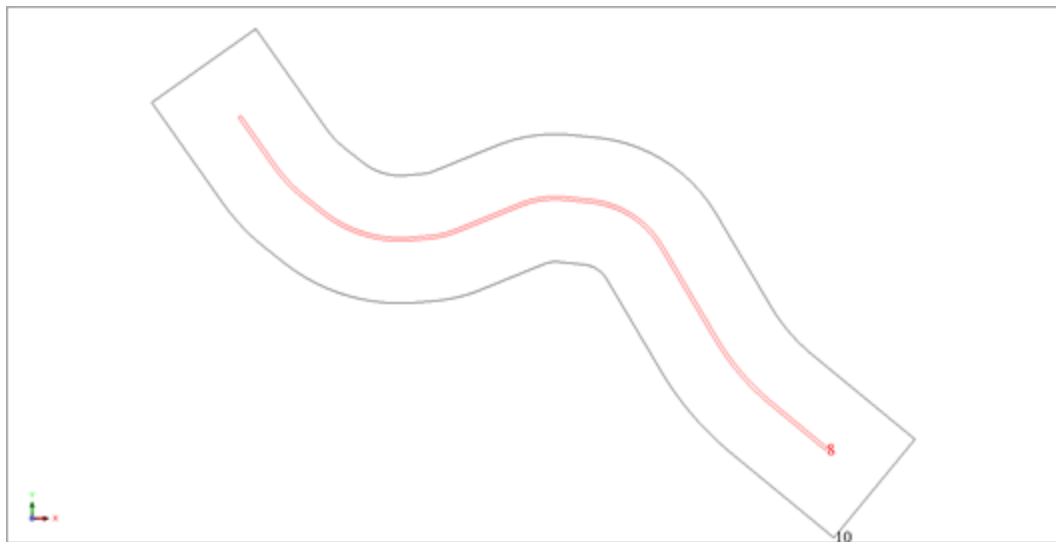
The expanded string is displayed.



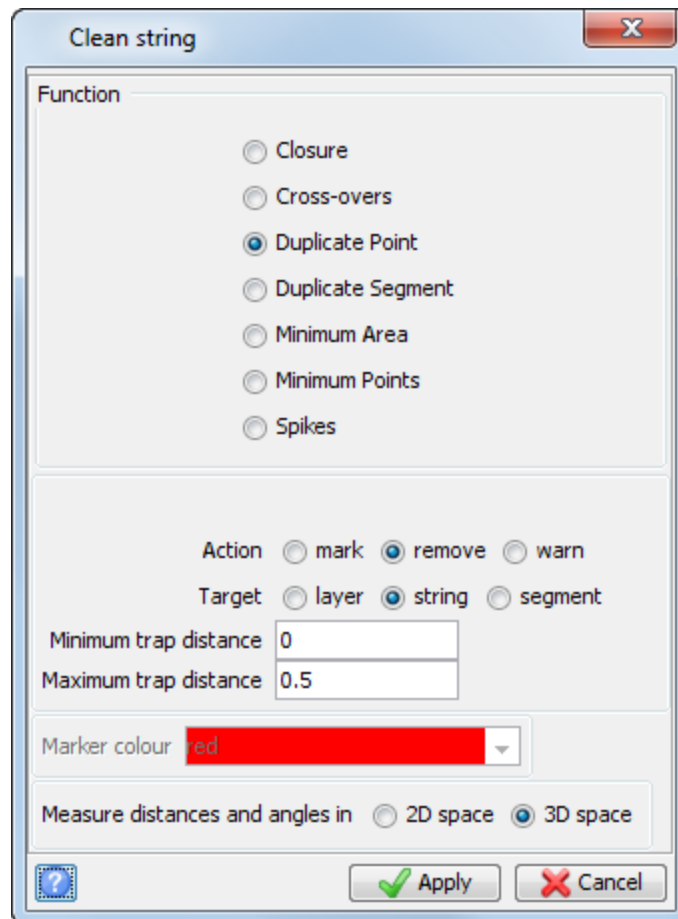
10. Press ESC.
11. Choose **Display > Strings > With string numbers**.
12. Enter the information as shown, and click **Apply**



The road outline with string 8 and string 10 displayed.



13. Choose **Edit > String > Clean**.
14. Enter the information as shown, and click **Apply**.



15. Click string 10.
16. Choose **Edit > String > Clean**.

17. Enter the information as shown, and click **Apply**.

Clean string

Function

- Closure
- Cross-overs
- Duplicate Point
- Duplicate Segment
- Minimum Area
- Minimum Points
- Spikes

Action  mark  remove  warn

Trap angle  degrees

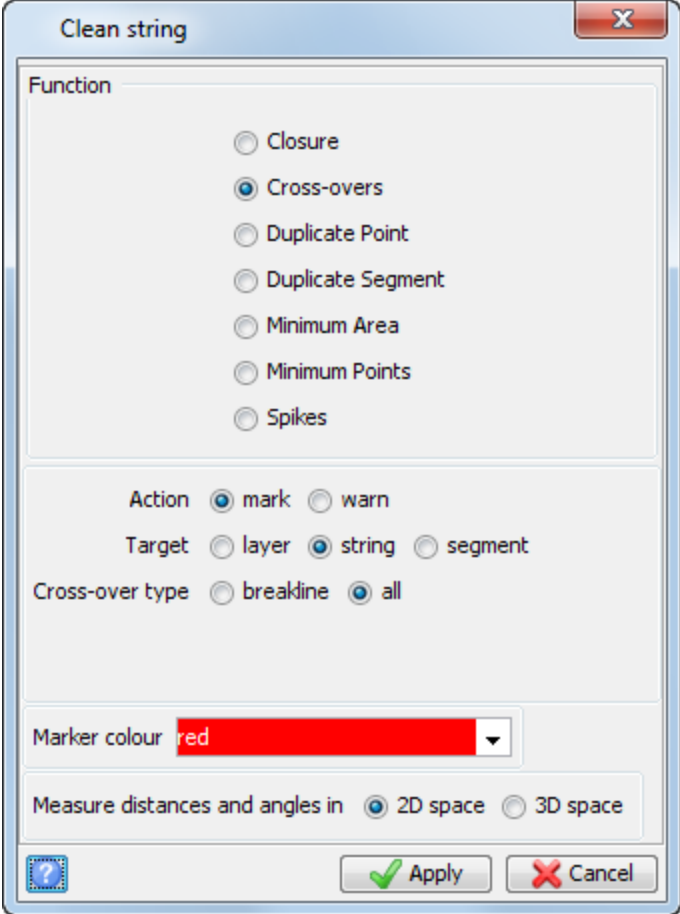
Target **segment**

Marker colour

Measure distances and angles in  2D space  3D space

18. Click string 10.

19. Choose **Edit > String > Clean**.
20. Enter the information as shown, and click **Apply**.



Clean string

Function

Closure

Cross-overs

Duplicate Point

Duplicate Segment

Minimum Area

Minimum Points

Spikes

Action  mark  warn


Target  layer  string  segment

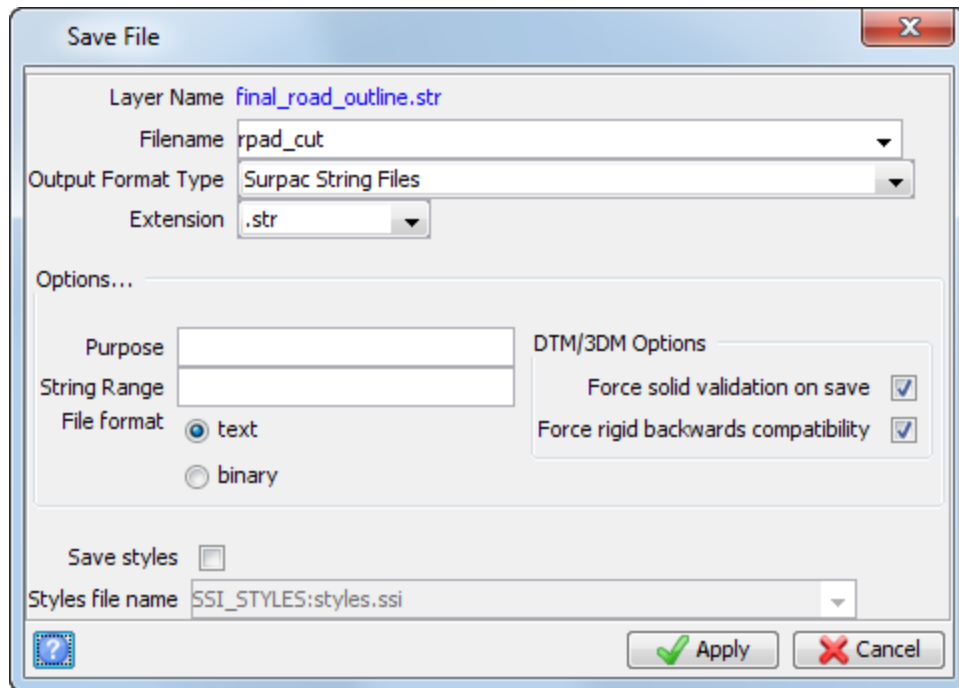
Cross-over type  breakline  all

Marker colour red

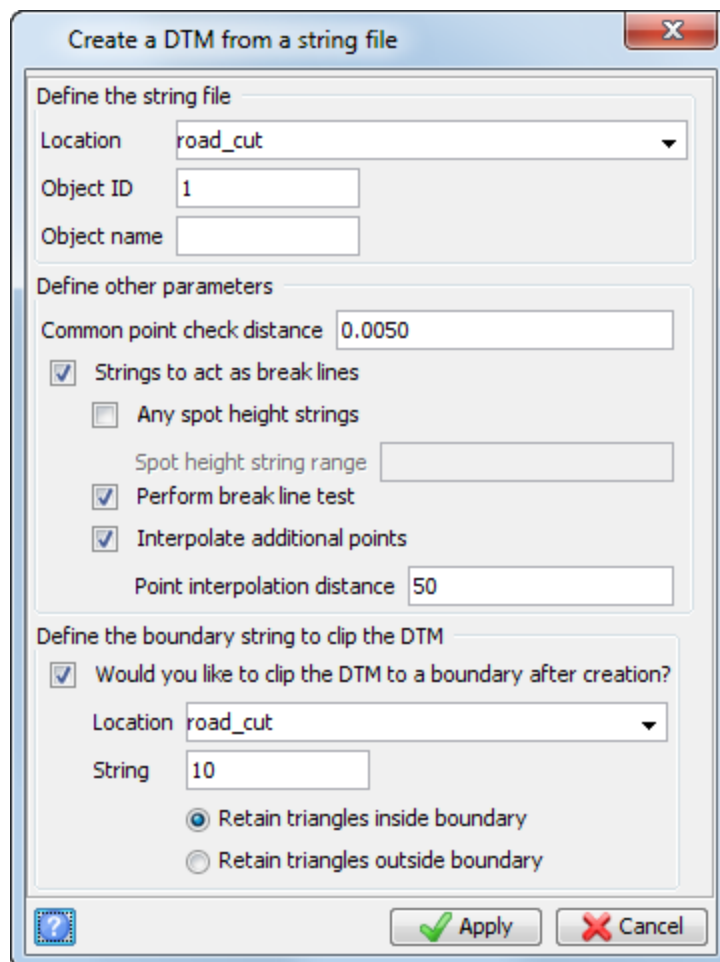
Measure distances and angles in  2D space  3D space

Apply Cancel

21. Click string 10.
22. Click **Save** .
23. Enter the information as shown, and click **Apply**.



24. Choose **Surfaces > DTM File functions > Create DTM from string file**.
25. Enter the information as shown, and click **Apply**.




The road cut log report is displayed.

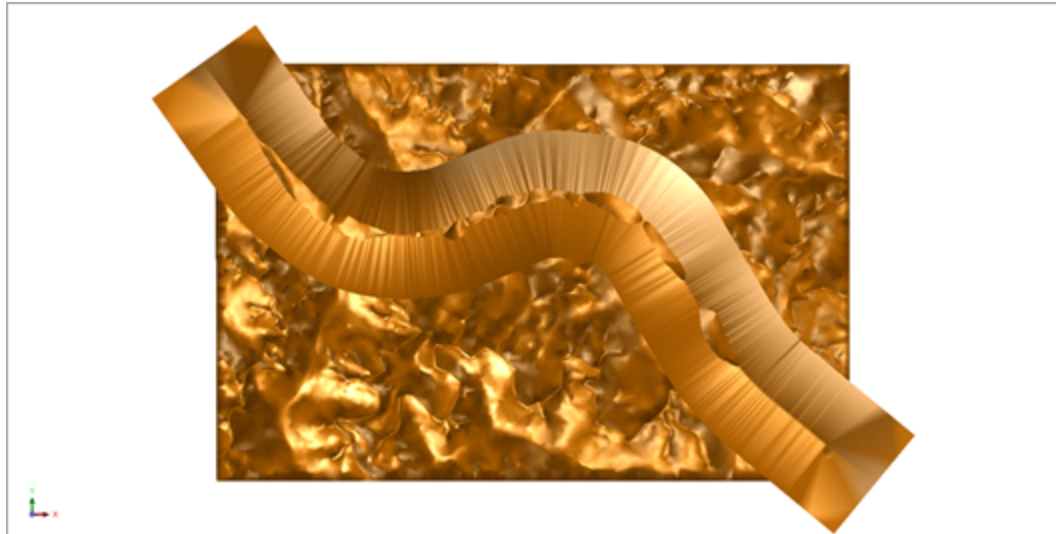
```


-----
DTM FORMATION
-----

DTM formed from      : road_cut.str
DTM File             : road_cut.dtm
Object ID            : 1
Number of Triangles  : 3203
Maximum/Minimum E   : 20229.026 / 17772.949
Maximum/Minimum N   : 58045.751 / 56410.263
Maximum/Minimum Z   : 5797.546 / 5102.469
Strings to act as breaklines : Y
Perform breakline test : Y
Point interpolation distance : 50
Common point check distance : 0.005


```

26. Click **Reset graphics** .
  27. Open **road\_cut.dtm** in **Graphics**.
  28. Open **topo.dtm** in **Graphics**.
- The DTM is displayed.



 **Note:** To see all the steps performed in this section, run **3a\_road\_cut\_dtm.tcl**. You need to click **Apply** on any forms presented.

### Task: Calculate road cut volume

1. Click **Reset graphics** .
2. Open **road\_cut.dtm** in **Graphics**.
3. Open **topo.dtm** in **Graphics**.
4. Choose **Surfaces > DTM File functions > Line of intersection between 2 DTMs**.

5. Enter the information as shown, and click **Apply**.

**Intersect DTMs for line of contact**

Define first DTM

Location: road\_cut

Object ID: 1

Trisolation ID: 1

Define second DTM

Location: topo

Object ID: 1

Trisolation ID: 1

Define the output file


Location: road\_cut\_boundary

String number: 1

Apply Cancel

6. If prompted, click **Yes** to overwrite the file.

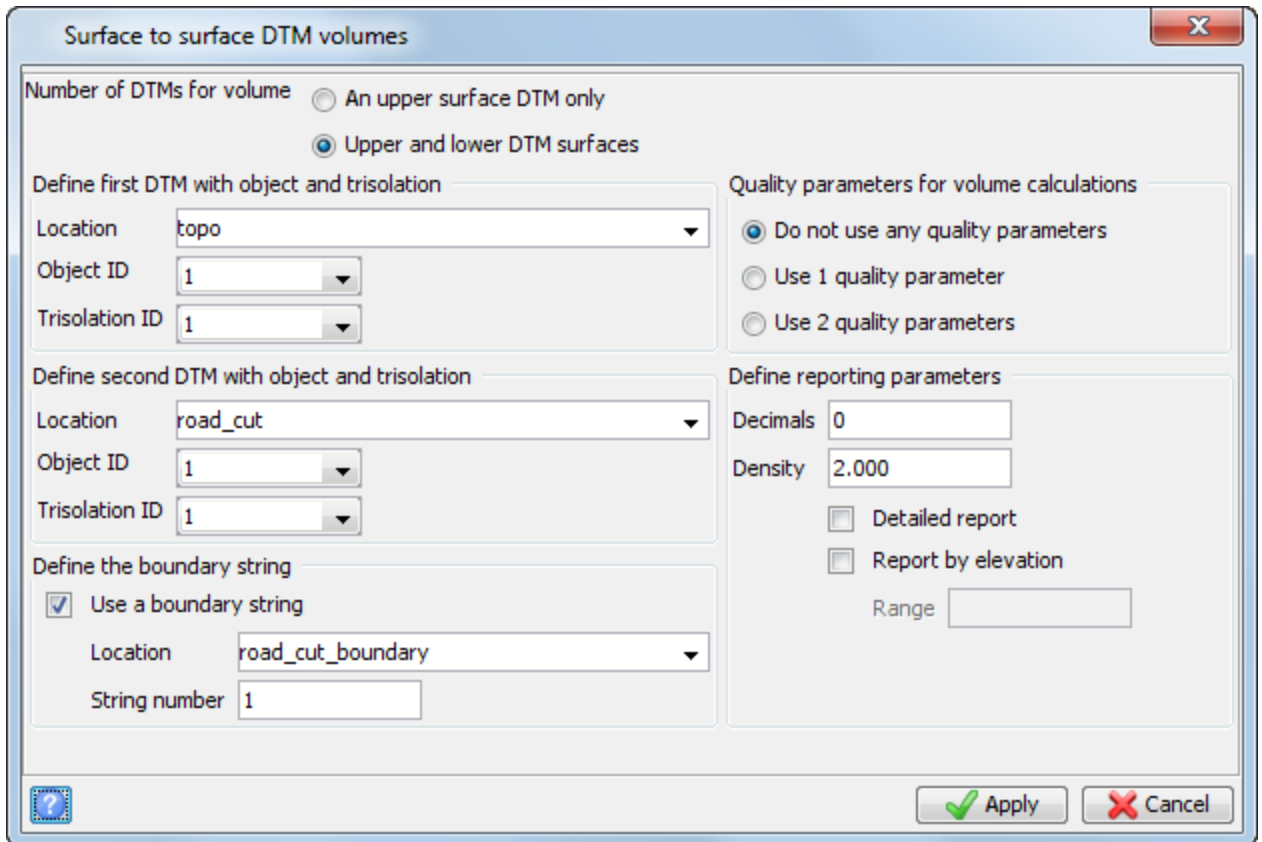
**Verify creation of file**

 You are about to overwrite the file:  
**road\_cut\_boundary.str**

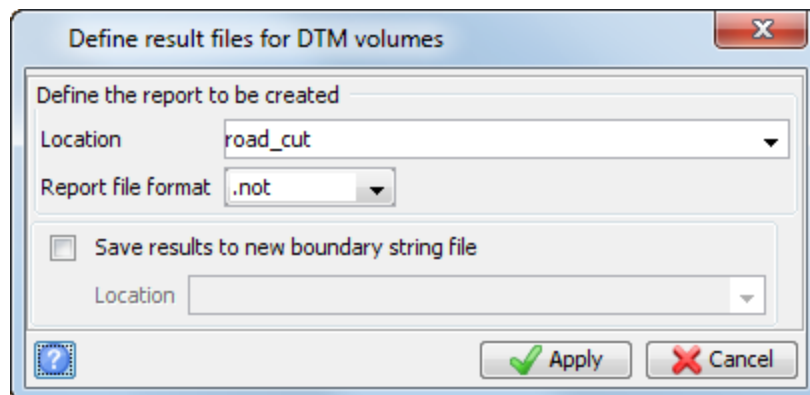
Select YES to overwrite the file or NO to cancel this operation.

Yes No

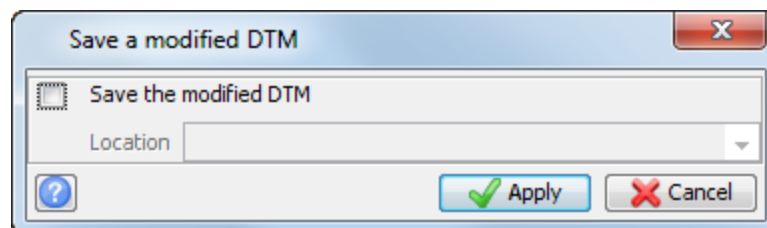
7. Choose **Surfaces > Volumes > Net volume between DTMs**.
8. Enter the information as shown, and click **Apply**.



9. Enter the information as shown, and click **Apply**.



10. Enter the information as shown, and click **Apply**



The road cut volume report is displayed.

```

VOLUME BETWEEN DTM SURFACES


Upper surface: topo.dtm
Upper surface object ID: 1
Upper surface trisolation ID: 1
Lower surface: road_cut.dtm
Lower surface object ID: 1
Lower surface trisolation ID: 1

Boundary file: road_cut_boundary.str
Boundary string: 1
Number of segments: 13
Density: 2


Volumes
Segment 1:
  (Volume) 0
  (Tonnage) 0
Segment 2:
  (Volume) 1270
  (Tonnage) 2540
Segment 3:
  (Volume) 207187
  (Tonnage) 414375
Segment 4:
  (Volume) 1
  (Tonnage) 2
Segment 5:
  (Volume) 0
  (Tonnage) 0
Segment 6:
  (Volume) 263011
  (Tonnage) 526021
Segment 7:
  (Volume) 128661
  (Tonnage) 257322
Segment 8:
  (Volume) 6669
  (Tonnage) 13339
Segment 9:
  (Volume) 336417
  (Tonnage) 672834
Segment 10:
  (Volume) 1417
  (Tonnage) 2834
Segment 11:
  (Volume) 378128
  (Tonnage) 756256
Segment 12:
  (Volume) 414220
  (Tonnage) 828440
Segment 13:
  (Volume) 349
  (Tonnage) 698
Total: 1737331

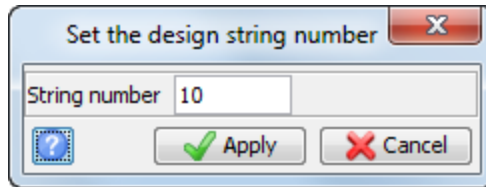
Page 1 of 1

```

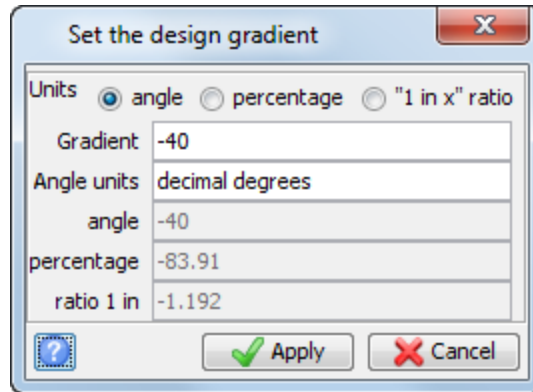
 **Note:** To see all the steps performed in this section, run `3b_road_cut_volume.tcl`. You need to click **Apply** on any forms presented.

### Task: Calculate road fill

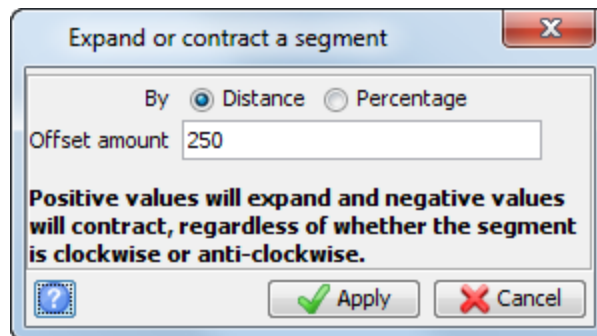
1. Click **Reset graphics** .
2. Open `final_road_outline.str` in **Graphics**.
3. Click the **Design string**  button on the Status bar.
4. Enter the information as shown, and click **Apply**.



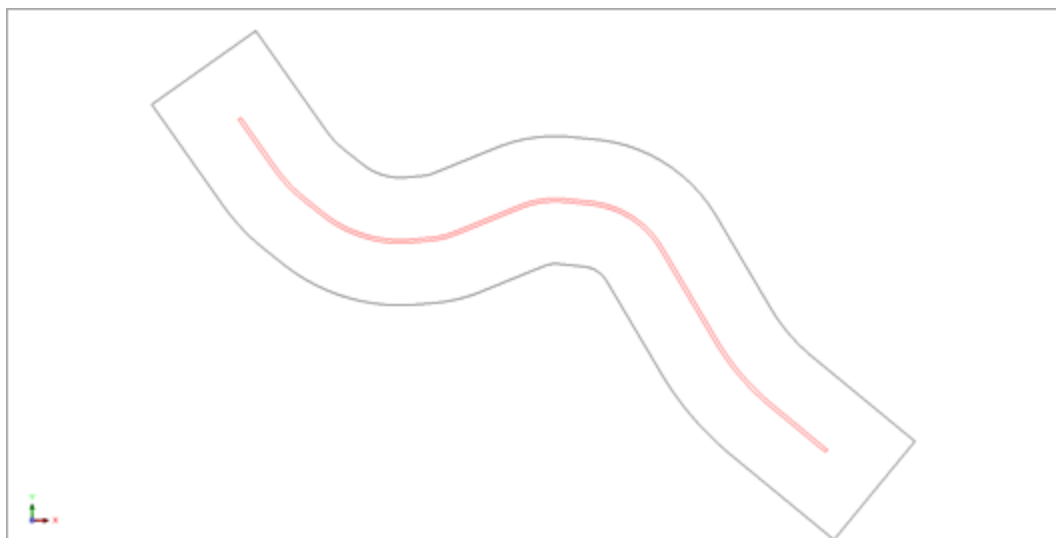
5. Click the **Design slope** 0.000 angle button on the Status bar.
6. Enter the information as shown, and click **Apply**.



7. Choose **Edit > Segment > Expand/Contract**.
8. Click the string.
9. Enter the information as shown, and click **Apply**.

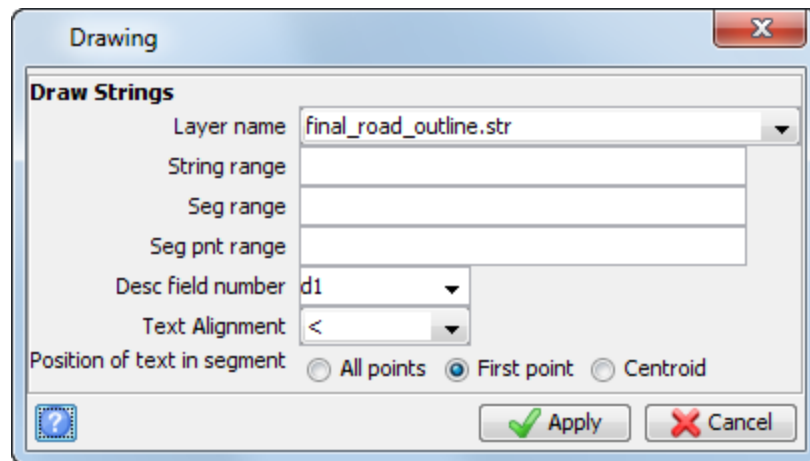


The expanded string is displayed.

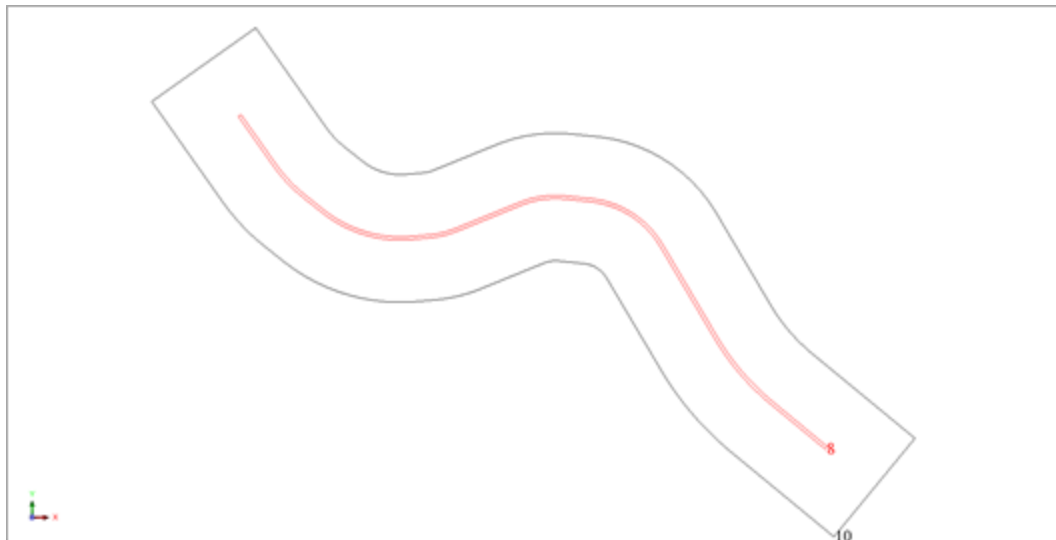


10. Click ESC.

11. Choose **Display > Strings > With string numbers.**
12. Enter the information as shown, and click **Apply.**



The road outline with string 8 and string 10 displayed.



13. Choose **Edit > String > Clean**.
14. Enter the information as shown, and click **Apply**.

**Clean string**

Function

Closure

Cross-overs

Duplicate Point

Duplicate Segment

Minimum Area

Minimum Points

Spikes

Action  mark  remove  warn

Target  layer  string  segment

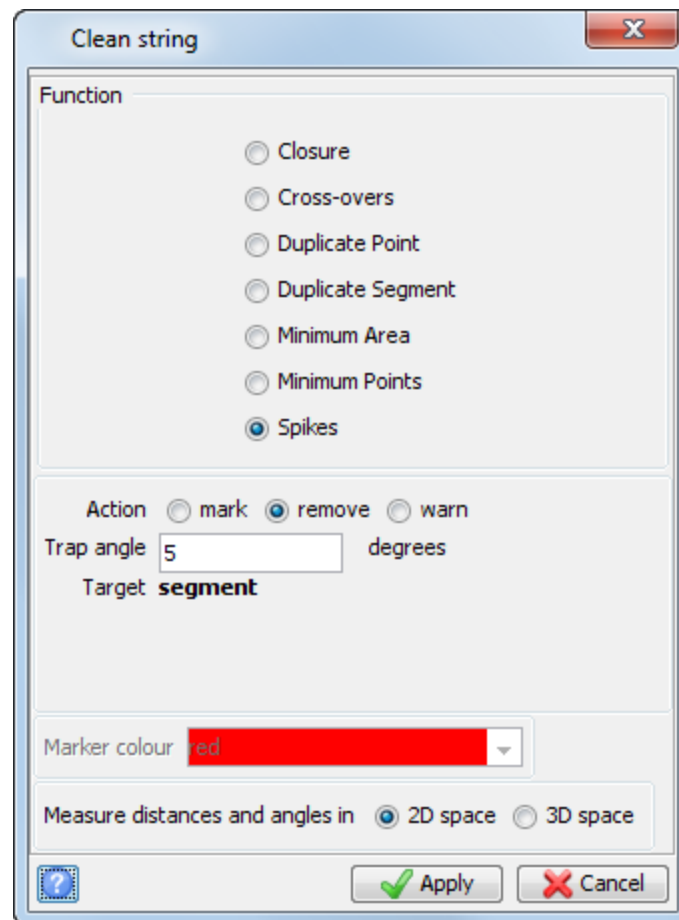
Minimum trap distance

Maximum trap distance

Marker colour

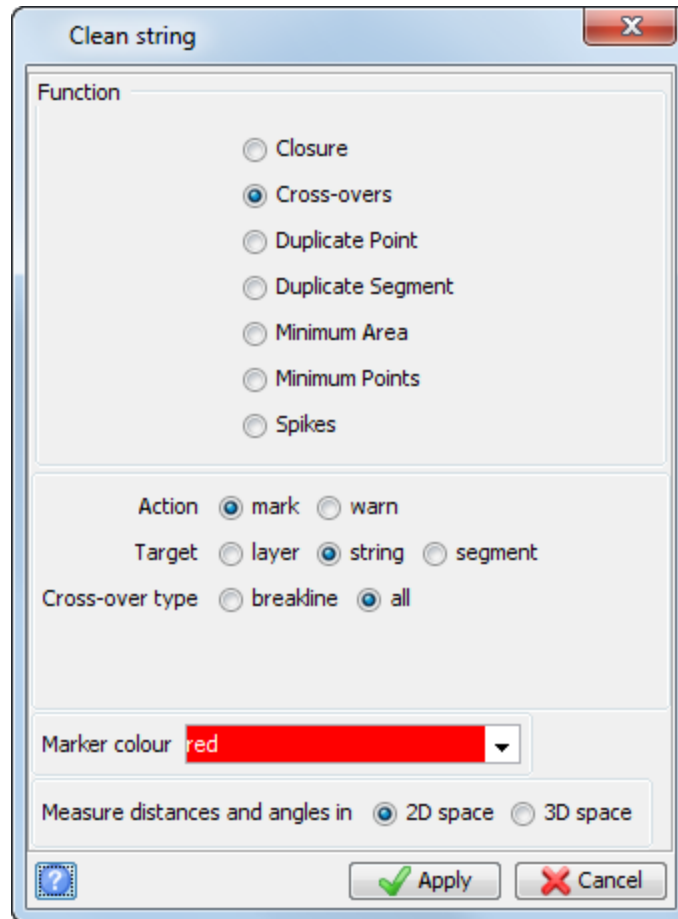
Measure distances and angles in  2D space  3D space

15. Click string 10.
16. Choose **Edit > String > Clean**.
17. Enter the information as shown, and click **Apply**.



18. Click string 10.
19. Choose **Edit > String > Clean**.

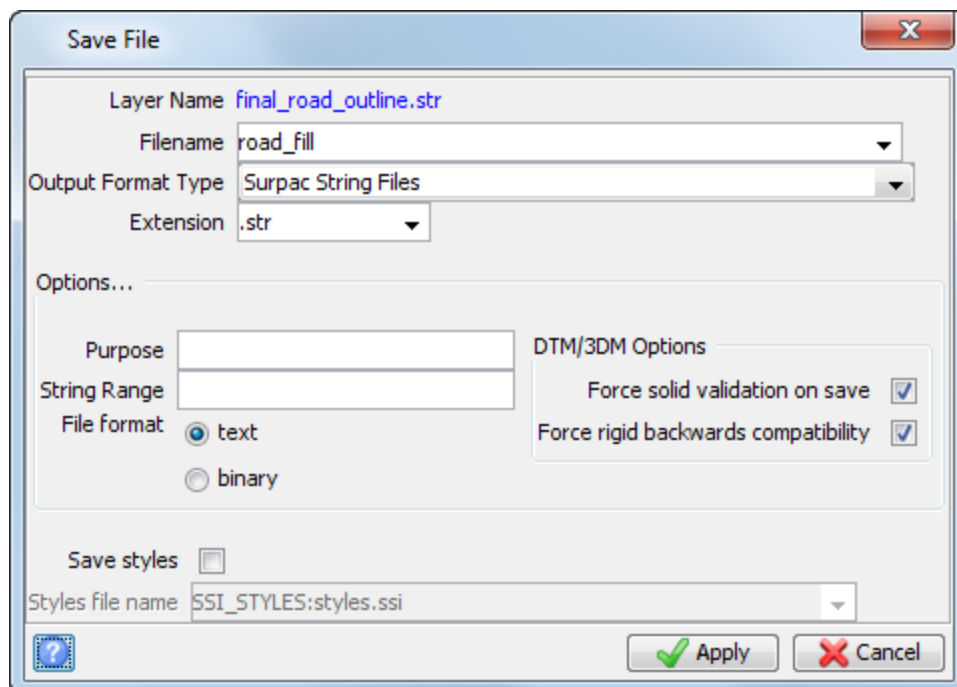
20. Enter the information as shown, and click **Apply**.



21. Click string 10.

22. Click **Save** .

23. Enter the information as shown, and click **Apply**.



24. Choose **Surfaces > DTM File functions > Create DTM from string file**.
25. Enter the information as shown, and click **Apply**.

The road fill log report is displayed.

```


-----
DTM FORMATION
-----

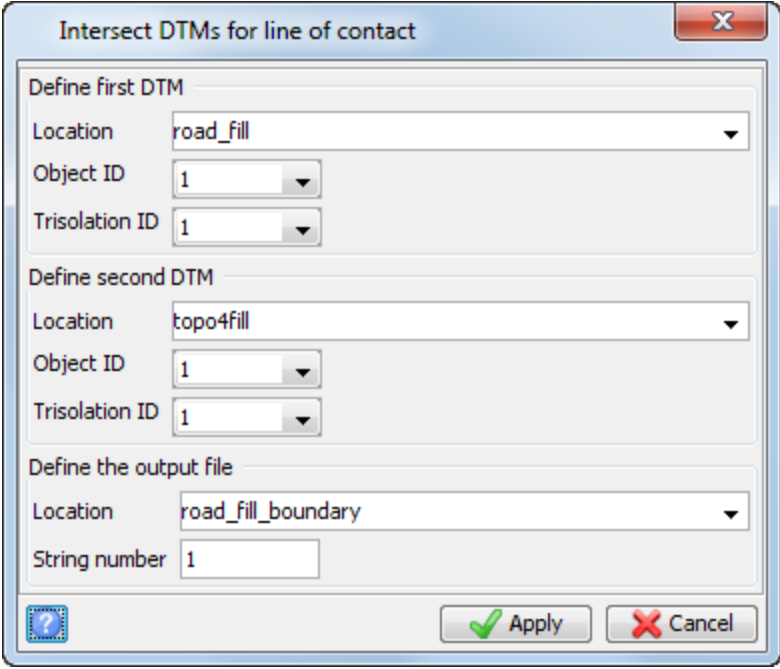
DTM formed from      : road_fill.str
DTM File             : road_fill.dtm
Object ID            : 1
Number of Triangles  : 3135
Maximum/Minimum E   : 20299.409 / 17703.258
Maximum/Minimum N   : 58115.447 / 56339.884
Maximum/Minimum Z   : 5368.645 / 4892.694
Strings to act as breaklines : Y
Perform breakline test : Y
Point interpolation distance : 50
Common point check distance : 0.005

```

**Note:** To see all the steps performed in this section, run **3c\_road\_fill\_dtm.tcl**. You need to click **Apply** on any forms presented.

**Task: Calculate road fill volume**

1. Click **Reset graphics** .
2. Open **road\_fill.dtm** in **Graphics**.
3. Open **topo4fill.dtm** in **Graphics**.
4. Choose **Surfaces > DTM File functions > Line of intersection between 2 DTMs**.
5. Enter the information as shown, and click **Apply**.



**Intersect DTMs for line of contact**

Define first DTM

Location: road\_fill

Object ID: 1

Trisolation ID: 1

Define second DTM

Location: topo4fill

Object ID: 1

Trisolation ID: 1

Define the output file

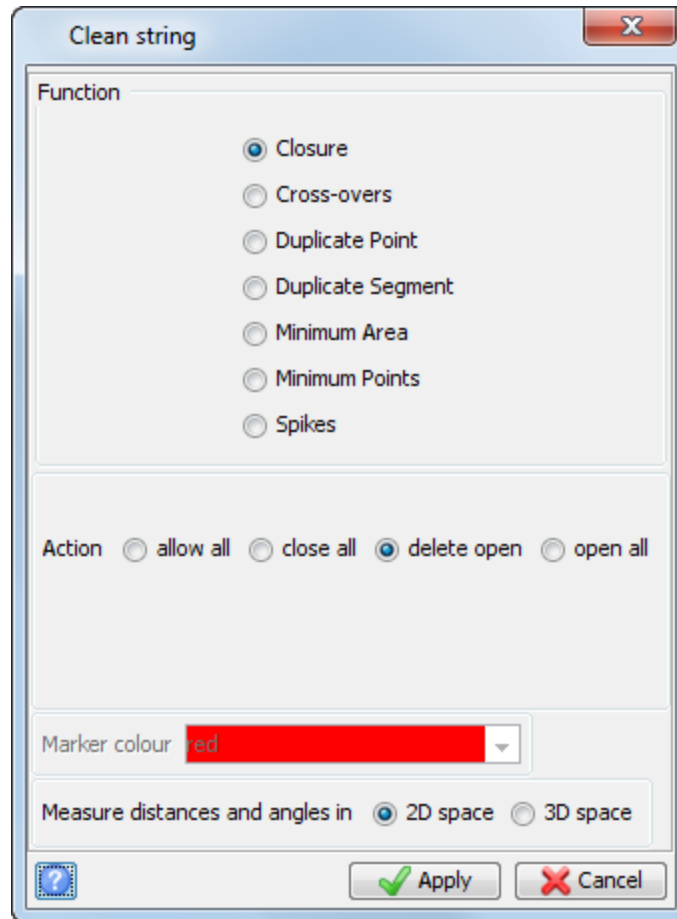
Location: road\_fill\_boundary

String number: 1

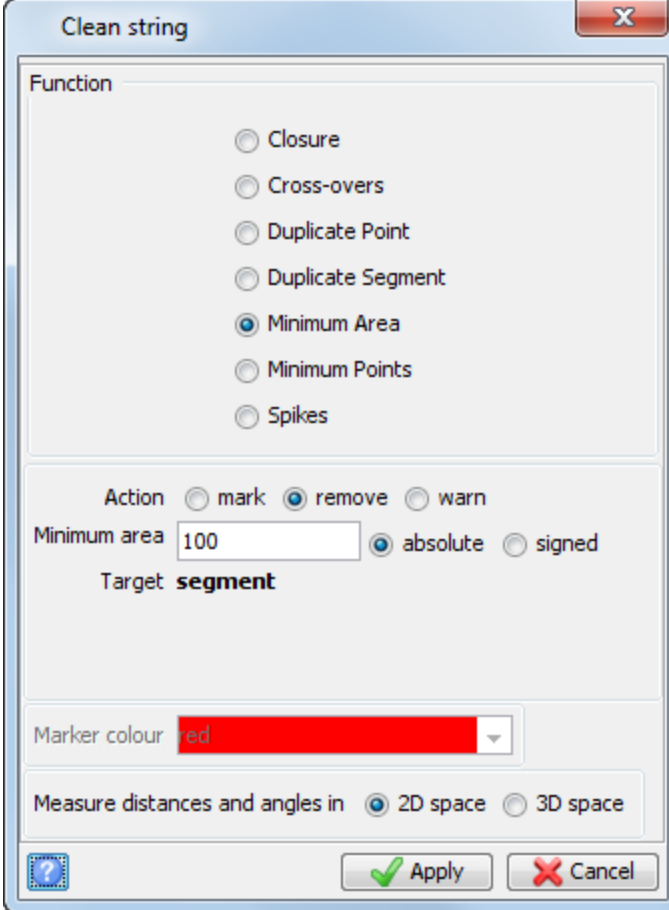
Apply Cancel

6. Choose **View > Surface view options > Hide triangle faces** to hide the face attributes.
7. Drag **road\_fill\_boundary.str** into **Graphics**.

8. Choose **Edit > String > Clean**.
9. Enter the information as shown, and click **Apply**.



10. Click the string.
11. Choose **Edit > String > Clean**.
12. Enter the information as shown, and click **Apply**.



**Clean string**

Function

Closure

Cross-overs

Duplicate Point

Duplicate Segment

Minimum Area

Minimum Points

Spikes


Action  mark  remove  warn

Minimum area   absolute  signed

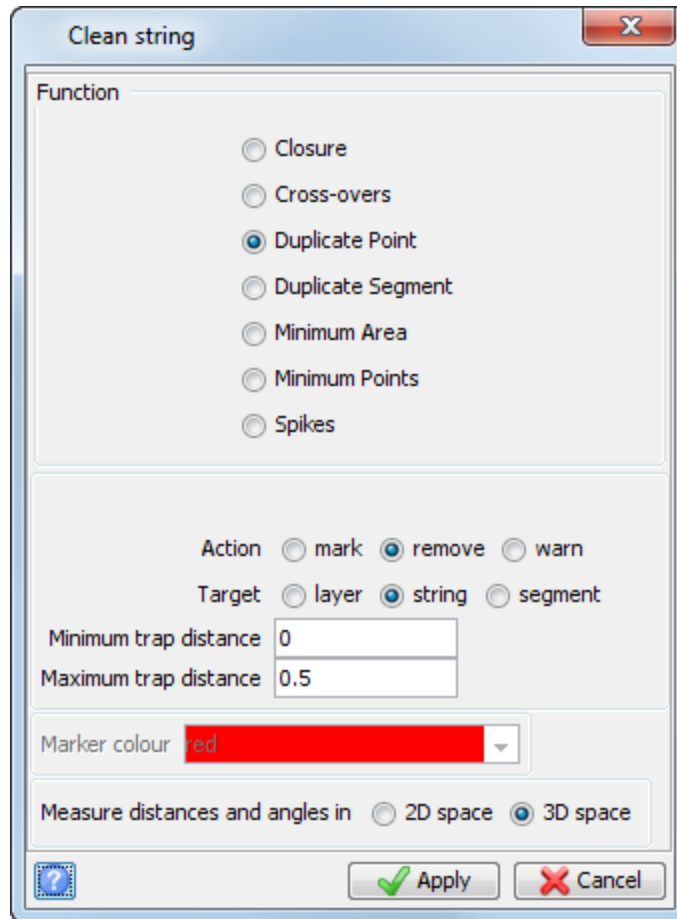
Target **segment**

Marker colour

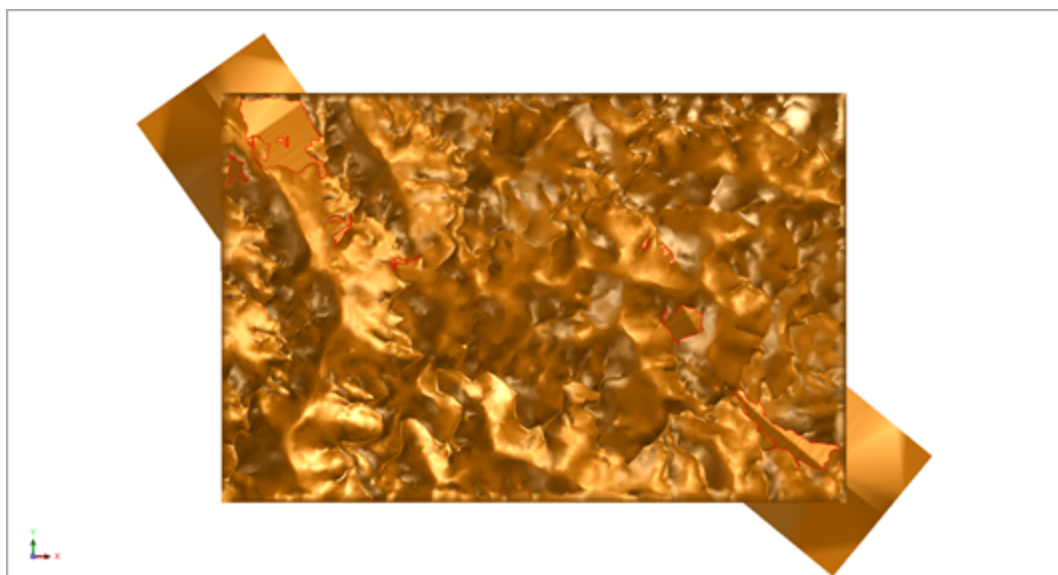
Measure distances and angles in  2D space  3D space



13. Click the string.
14. Choose **Edit > String > Clean**.
15. Enter the information as shown, and click **Apply**.

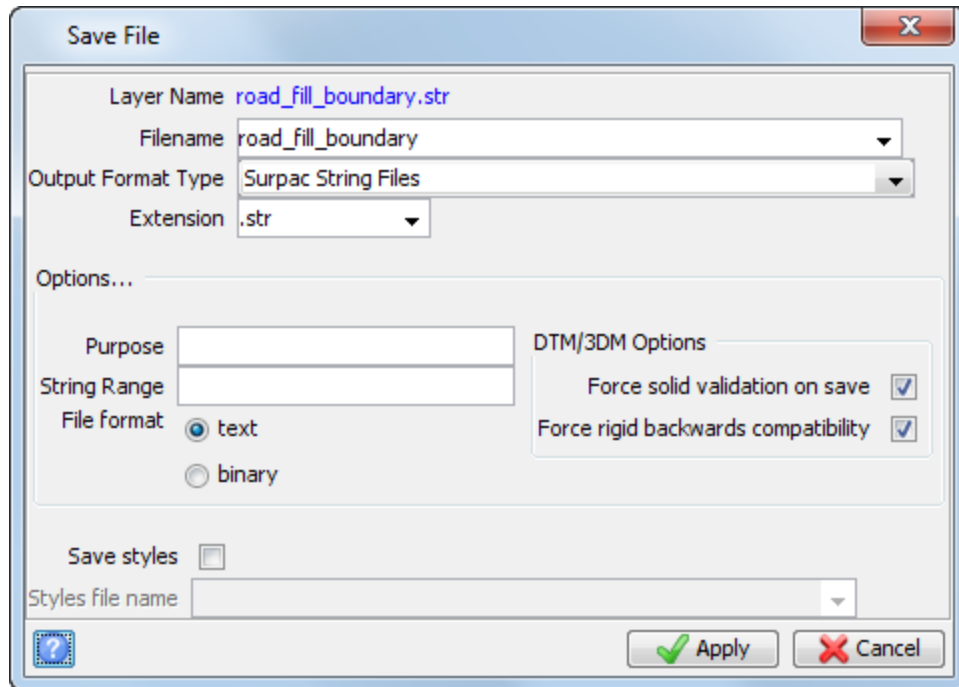


16. Click the string.
17. Choose **View > Surface view options > Hide triangle faces** to display the face attributes. The DTM is displayed.



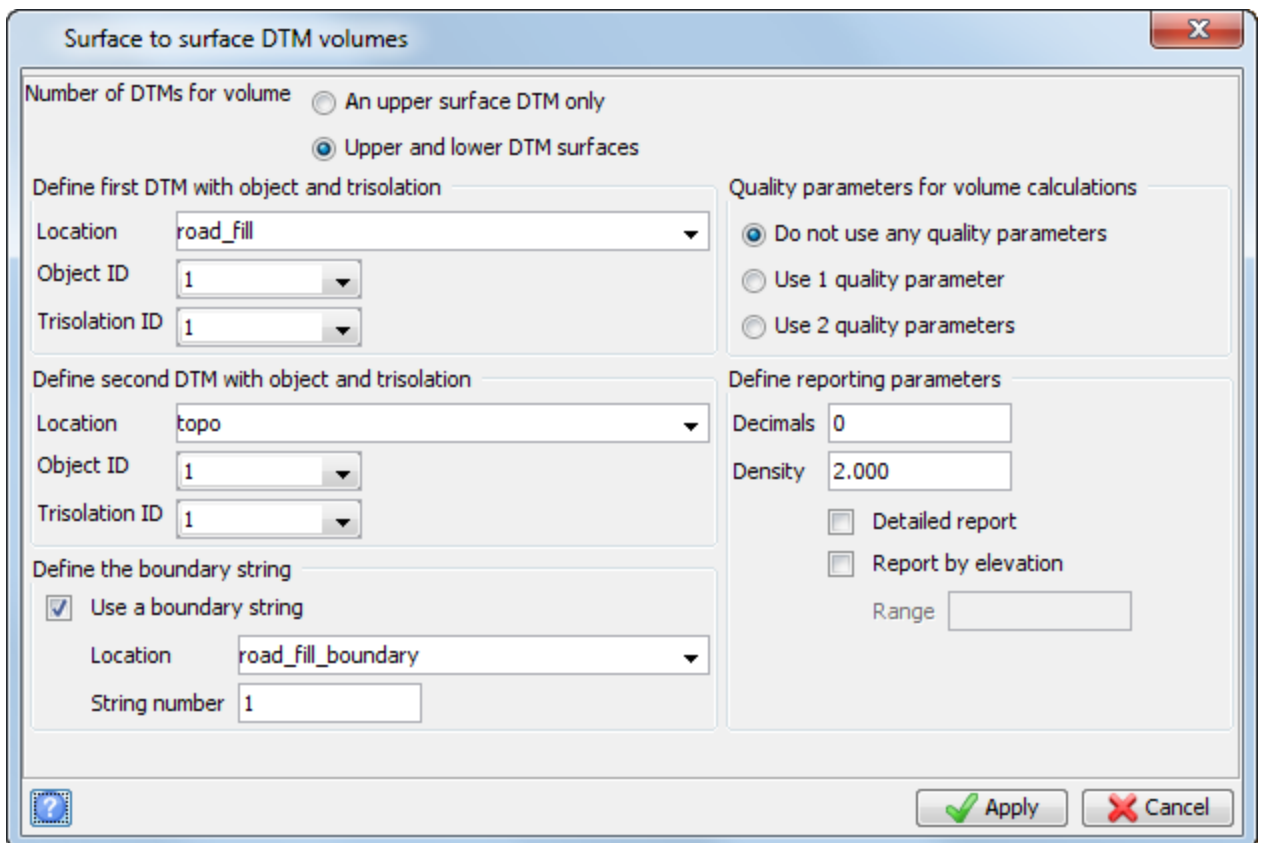
18. Click **Save** .

19. Enter the information as shown, and click **Apply**.

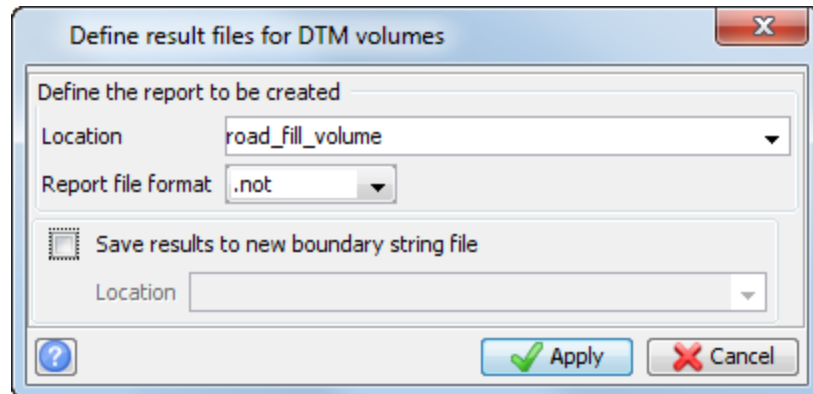


20. Choose **Surfaces > Volumes > Net volume between DTMs**.

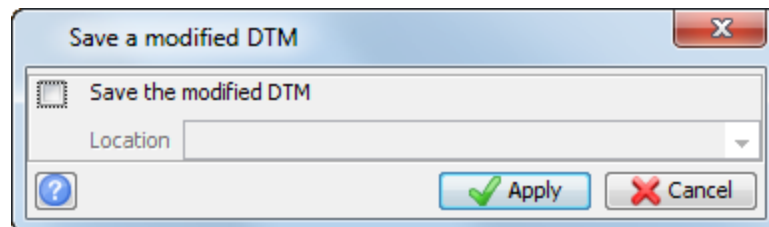
21. Enter the information as shown, and click **Apply**.



22. Enter the information as shown, and click **Apply**.



23. Enter the information as shown, and then click **Apply**.



The road fill volume report is displayed.

```


VOLUME BETWEEN DTM SURFACES

Upper surface: road_fill.dtm
Upper surface object ID: 1
Upper surface trisolation ID: 1
Lower surface: topo.dtm
Lower surface object ID: 1
Lower surface trisolation ID: 1

Boundary file: road_fill_boundary.str
Boundary string: 1
Number of segments: 13
Density: 2

Volumes
Segment 1:
  (Volume) 392093.38
  (Tonnage) 784186.76
Segment 2:
  (Volume) 1615.00
  (Tonnage) 3229.99
Segment 3:
  (Volume) 6247.39
  (Tonnage) 12494.79
Segment 4:
  (Volume) 190369.49
  (Tonnage) 380738.98
Segment 5:
  (Volume) 1744.72
  (Tonnage) 3489.43
Segment 6:
  (Volume) 1798.76
  (Tonnage) 3597.52
Segment 7:
  (Volume) -681.71
  (Tonnage) -1363.41
Segment 8:
  (Volume) 217.21
  (Tonnage) 434.43
Segment 9:
  (Volume) 15233.43
  (Tonnage) 30466.85
Segment 10:
  (Volume) 1160382.00
  (Tonnage) 2320764.00
Segment 11:
  (Volume) 201.52
  (Tonnage) 403.05
Segment 12:
  (Volume) 1473.06
  (Tonnage) 2946.12
Segment 13:
  (Volume) 12131.43
  (Tonnage) 24262.86
Total: 1782825.68

```

 **Note:** To see all the steps performed in this section, run **3d\_road\_fill\_volume.tcl**. You need to click **Apply** on any forms presented.