

ArcGIS® 9

Linear Referencing in ArcGIS®



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DATA CREDITS

Highways and streets map—Maryland Department of Transportation State Highway Administration, Baltimore, Maryland

Transit map—Parsons Brinckerhoff Quade & Douglas, Inc., Los Angeles, California

Railways map—Parsons Brinckerhoff Quade & Douglas, Inc., Los Angeles, California

Oil and gas exploration map—TGS–NOPEC Geophysical Company, Houston, Texas

Pipelines map—M.J. Harden Associates, Inc., Kansas City, Missouri

Water resources map—Center for Research in Water Resources, University of Texas at Austin

Hatching map 1—New York State Department of Transportation, Albany, New York

Hatching map 2—TGS–NOPEC Geophysical Company, Houston, Texas

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Quick-start tutorial

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ArcGIS has the tools you need for linear referencing applications. The easiest way to start learning about linear referencing is to complete the exercises in this tutorial. Before you start, however, it is assumed you know the fundamentals of ArcGIS software. For more information, see *Geoprocessing in ArcGIS*, *Using ArcCatalog*, *Using ArcMap*, and *Editing in ArcMap*.

For this tutorial, imagine that you work in the GIS department of a highway authority responsible for the maintenance and safety of your region's highways. In the exercises to follow, you will perform some of the linear referencing tasks typical to such a person. Specifically, you will use the linear referencing tools in ArcToolbox™ to create and recalibrate route data. Next, you will learn how to display and query your newly created route data in ArcMap™. After that, you will discover how easy it is to display and query your route event data in ArcMap. Lastly, you will learn how to edit your route data in ArcMap.

The licenses required to complete each exercise vary from ArcView® to ArcEditor™ to ArcInfo™. If you require a license different from ArcView, it will be indicated at the top of the page. Even if you don't have the appropriate license, feel free to read through the exercises to familiarize yourself with the linear referencing functionality in ArcGIS.

This tutorial includes five exercises, each of which takes five to 30 minutes to complete. The exercises build on one another, so it is assumed that you will complete them in order.

The study area for this tutorial is Pitt County, North Carolina. The data was compiled from various sources and has been modified to suit the needs of the exercises. The reliability and suitability of the information, therefore, cannot be guaranteed.

Exercise 1: Organizing your data in ArcCatalog

The exercises in this chapter use the tutorial data distributed with ArcGIS and work with an ArcView license. Some of these exercises require you to make changes to the data, therefore, you will need to have write access to the data. To be sure you have write access, you will begin this exercise by making a working copy of the LinearReferencing tutorial folder.

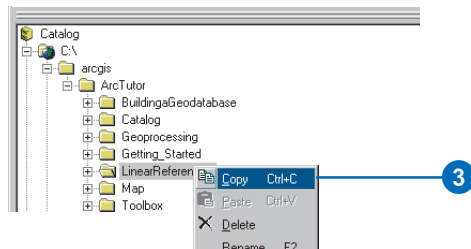
Copying the data

1. Start ArcCatalog™ by either double-clicking a shortcut installed on your desktop or using the Programs list in your Start menu.
2. Navigate to the LinearReferencing folder on the local drive where the tutorial data is installed, for example, C:\arcgis\ArcTutor\LinearReferencing.

If the data was installed by your system administrator in a shared folder on the network, the path to the tutorial folder includes the names of the computer and the connection through which the folder is accessed, for example,

\\dataserver\public\ArcGIS\ArcTutor\LinearReferencing.

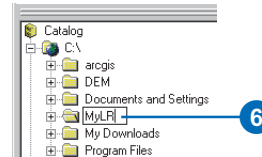
3. Right-click the Linear Referencing folder and click Copy.



4. Navigate to the location where you would like to make a copy of this data, such as C:\.
5. Right-click this location and click Paste.

A new folder called Linear Referencing will be created at this location.

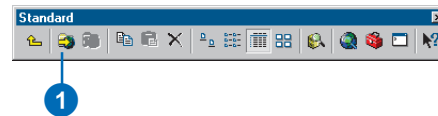
6. Right-click this new folder and click Rename. Enter “MyLR” as the new folder name.



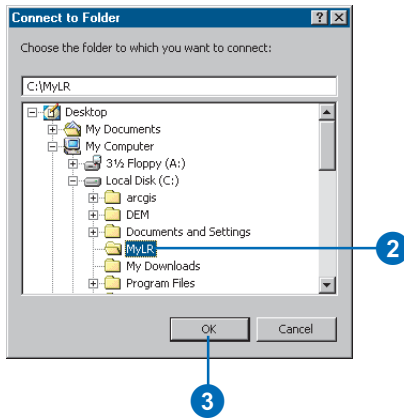
Connect directly to your tutorial data

In ArcCatalog, folder connections let you access specific directories on local disks or shared folders on the network. Further, database connections allow you to access the contents of a database.

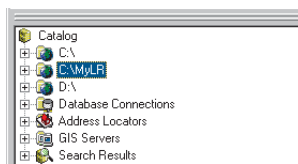
1. Click the Connect To Folder button on the Standard toolbar.



2. Navigate to and select your location of MyLR.
3. Click OK.



The new folder connection is now listed in the Catalog tree. You will now be able to access all of the data needed for the remaining exercises in this tutorial via the new connection.



ArcInfo and ArcEditor

Exercise 2: Creating and calibrating route data

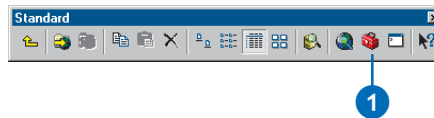
The first thing you will need for any linear referencing project is accurate route data. In this exercise, you use ArcToolbox tools to create and calibrate route data. The first activity is to create a temporary layer representing only the line features that have route and measure information stored as attribute values. Next, you will create a route feature class by merging the input line features of the temporary layer that share a common route identifier. Finally, you will recalibrate the newly created routes using a point feature class storing route and measure information as attributes.

Creating a layer

Not every feature in the base_roads feature class has route and measure information. Therefore, before any routes are created, you will want to isolate only those routes that contain this information. Creating routes using features that do not have this information would be pointless.

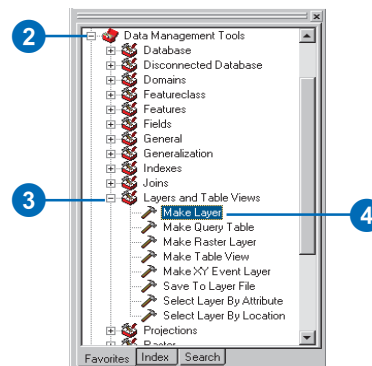
Creating a temporary layer allows you to do things, such as make selections, without affecting the original data source. This layer will not appear in the ArcCatalog contents, because it is created in-memory and simply references the data stored on disk. These layers can be used as inputs to other geoprocessing tools within your working session. Once you exit the application the in-memory layers will be removed.

1. In ArcCatalog, show the ArcToolbox window by clicking the Show/Hide ArcToolbox button on the Standard toolbar.



You can click the top of the ArcToolbox window and drag it around the ArcCatalog window to dock it where you prefer. Also try double-clicking the top of the window to undock or dock it.

2. Expand the Data Management Tools toolbox to show its contents.
3. Expand the Layers and Table Views toolset to show its contents.
4. Right-click the Make Feature Layer tool and click Open. Alternatively you can double-click the Make Feature Layer tool to open it.

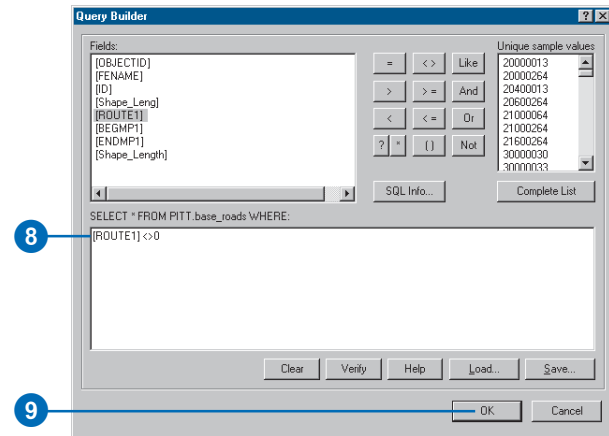
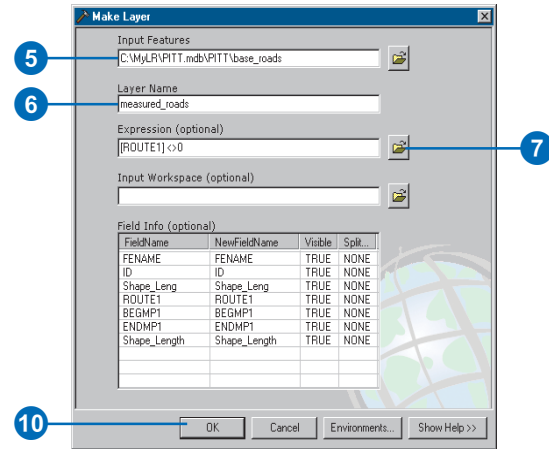


ArcInfo and ArcEditor

There are several ways to set the input feature class. You can drag a feature class from the ArcCatalog tree and drop it onto the text box, click the Browse button and navigate to the feature class in the dialog box, or simply type the full pathname to the feature class in the text box.

The tutorial instructions will simply ask you to type names and paths into the appropriate text boxes. Feel free, however, to use any of the available techniques.

5. Type “C:\MyLR\PITT.mdb\PITT\base_roads” for the value of the Input Features parameter.
6. Type “measured_roads” for the value of the Layer Name parameter.
7. Click the Expression button to open the Query Builder dialog box.
8. Type “[ROUTE1] <> 0” in the text box.
9. Click OK on the Query Builder dialog box.
10. Click OK on the Make Layer dialog box.



The tool’s progress dialog box opens as the tool runs.

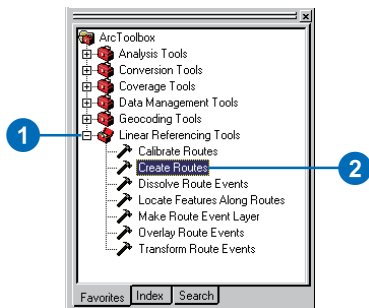
11. Click Close on the tool’s progress dialog box when the process is finished.

ArcInfo and ArcEditor

Creating route data

The Create Routes tool is used to specify the input line features, the route identifier field, the method used to set the route measures, and the output feature class. Note that the input features can be any supported format. This includes coverage, shapefile, personal and enterprise geodatabase, and *computer-aided design (CAD)* data.

1. Expand the Linear Referencing Tools toolset to show its contents.
2. Right-click the Create Routes tool and click Open.



3. Click the dropdown arrow for the Input Line Features and click the measured_roads layer.
4. Click the Route Identifier Field dropdown arrow and click ROUTE1. The values in the route identifier field uniquely identify each route.

Next, you need to specify the name for the output feature class. This feature class can be contained within the same geodatabase as the input, or you can save it to another geodatabase or shapefile. If it is saved to a geodatabase it can be contained within a feature dataset or on its own as a feature class. For this exercise you will be writing the new data to the same feature dataset as the input.

5. Type “C:\MyLR\PITT.mdb\PITT\routes” for the value of the Output Route Feature Class parameter.

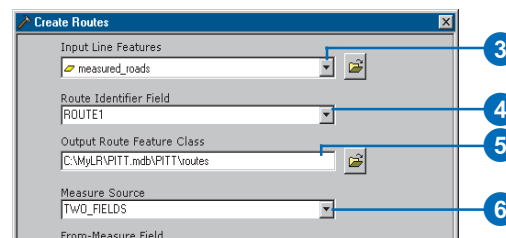
Next specify how the route measures will be obtained. There are three choices:

- Geometric lengths of the input features are used to accumulate the measures.
- Values stored in a measure field are used to accumulate the measures.
- Values stored in from- and to-measure fields are used to set the measures.

You will use the third method.

6. Click the Measure Source dropdown arrow and click TWO_FIELDS.

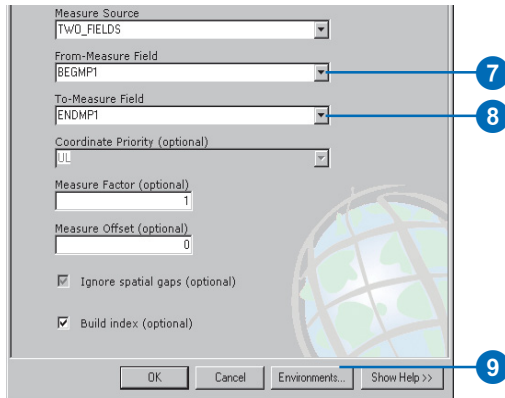
This will enable both the From- and To-Measure Field input fields.



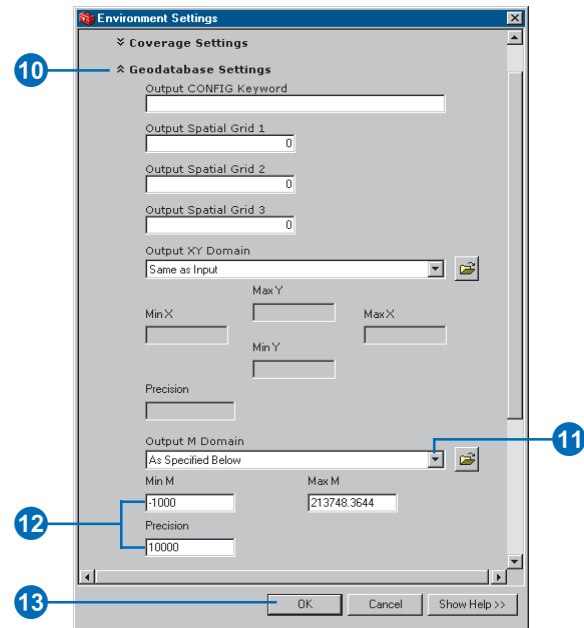
- Click the From-Measure Field dropdown arrow and click BEGMP1.
- Click the To-Measure Field dropdown arrow and click ENDMP1.

When you are writing to an existing feature dataset (as you are here), the spatial reference settings of that dataset will be applied to any new feature class. The exception to this rule is the m domain. Feature classes within the same feature dataset can have a different m domain. This accounts for the fact that different route feature classes might have different units of measure—for example, feet, meters, and miles. Whenever you create a route feature class in an existing feature dataset, you should always set an appropriate m domain. The spatial domain for a feature class or feature dataset cannot be changed. To learn more about the spatial reference, see later chapters in this book or *Building a Geodatabase*.

- Click Environments to access the spatial reference m domain settings.



- Expand Geodatabase Settings.
 - Click the Output M Domain dropdown arrow and click As Specified Below.
 - Type “-1000” for Min M and “10000” for Precision.
- The precision setting will ensure that your route measures will be accurate to four decimal places.
- Click OK to close each dialog box.



The tool’s progress dialog box opens as the tool runs.

- Click Close on the tool’s progress dialog box when the process is finished.

ArcInfo and ArcEditor

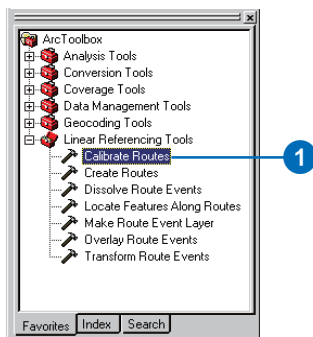
Calibrating route data

Imagine that at some point in the future, the highway authority's road maintenance crew acquired a distance measuring instrument (DMI) to accurately record mileage information along the highways. For a sample set of highways, the crew went out and captured mileage information approximately every 1/10 of a mile. The results of this effort were stored as points in a shapefile, where the route and mileage information was stored as attributes.

In the next section of this tutorial, you will use the Calibrate Routes tool to adjust the measures of the routes you just created to match those of the points in the shapefile. The result will be written to a new feature class.

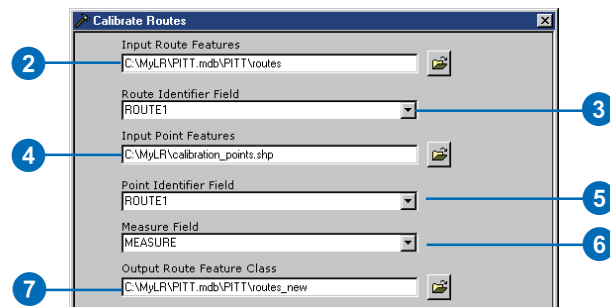
The Calibrate Routes tool is used to specify the input route feature class, the route identifier field, the input point feature class, the measure field, the methods used to set the route measures, and the output feature class.

1. Right-click the Calibrate Routes tool in the ArcToolbox Linear Referencing toolset, and click Open.



2. Type “C:\MyLR\PITT.mdb\PITT\routes” for the value of the Input Route Features parameter.

3. Click the Route Identifier Field dropdown arrow and click ROUTE1. The values in the Route Identifier Field uniquely identify each route.
4. Type “C:\MyLR\calibration_points.shp” for the value of the Input Point Features parameter.
5. Click the Point Identifier Field dropdown arrow and click ROUTE1. This is the common field, shared with the route feature class.
6. Click the Measure Field dropdown arrow and click MEASURE.
7. Type “C:\MyLR\PITT.mdb\PITT\routes_new” for the value of the Output Route Feature Class parameter.

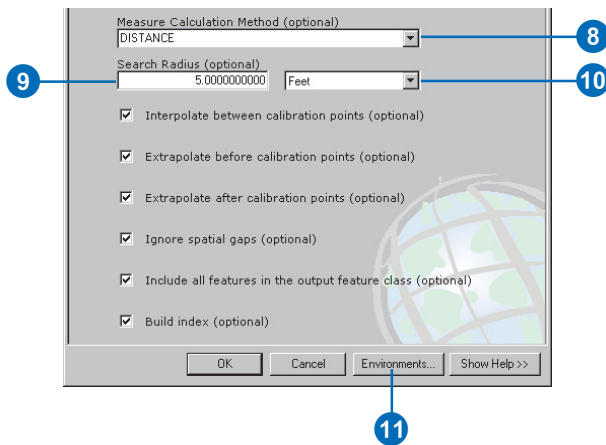


A tolerance can be specified to limit how far a calibration point can be from its route. Points outside the tolerance will not be used by the calibration process.

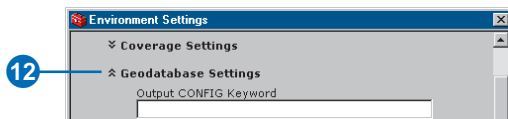
- Click the Measure Calculation Method dropdown arrow and click DISTANCE.
- Type “5” for the value of the Search Radius parameter. This is more than enough for the data that is being used here.
- Click the Search Radius dropdown arrow and click Feet, to set the units to feet.

Again, you are writing to an existing feature dataset. All spatial reference settings will be borrowed from that spatial reference. It is a good habit to set the m domain whenever writing route data to a geodatabase.

- Click Environments to access the spatial reference m domain settings.



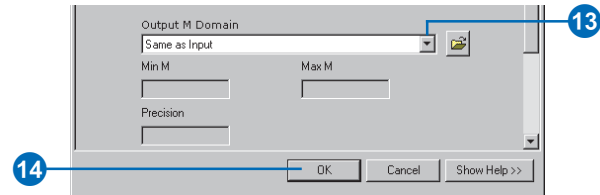
- Expand Geodatabase Settings.



- Click the Output M Domain dropdown arrow and click Same as Input.

You use the same m domain as the input route feature class. Note, however, that it is always a good practice to set the m domain.

- Click OK to close each dialog box.



The tool’s progress dialog box opens as the tool runs.

- Click Close on the tool’s progress dialog box when the process is finished.

In this exercise, you learned how to create a route feature class by merging input line features that shared a common identifier and how to adjust the route measures using measure information stored in a point shapefile. For more information on creating and calibrating route data, see Chapter 4, ‘Creating route data’.

Exercise 3: Displaying and querying routes

In this exercise, you will add the route data you created in Exercise 2 to an existing map document and symbolize it. You will then

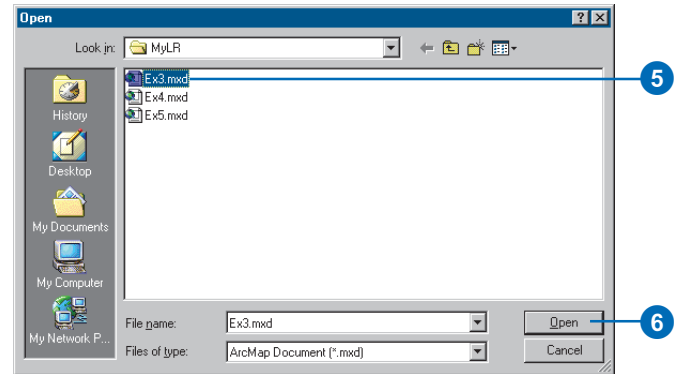
- Set the route identifier field.
- Add the Identify Route Locations tool to a toolbar.
- Identify route locations.
- Find route locations.
- Display route measure anomalies.

If you have not completed Exercise 2, open ArcCatalog. Within the Contents, delete PITT.mdb in your \MyLR folder and rename PITT_Results.mdb to PITT.mdb.

Opening an existing map document

To begin this exercise, you will start ArcMap and open an existing document.

1. Double-click a shortcut installed on your desktop or use the Programs list in your Start menu to start ArcMap.
2. In the Startup dialog box, choose to start using An existing map.
3. Double-click Browse for maps.
4. Click the Look in dropdown arrow in the Open dialog box and navigate to the folder where you copied the data for this tutorial (i.e., C:\MyLR).
5. Click Ex3.mxd to open the map in ArcMap.
6. Click Open.

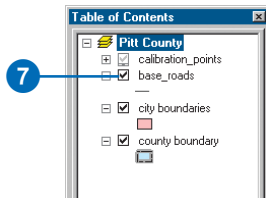


This map contains the following layers in a data frame called Pitt County:

calibration_points	The points used in Exercise 2 to recalibrate the route measures
base_roads	All of the roads in Pitt County
city boundaries	The boundaries of the cities in Pitt County
county boundary	Pitt County boundary

The map currently displays the city boundaries and county boundary layers. Their check boxes are checked in the table of contents. The calibration_points layer is checked, but scale suppression has been set. It will only be visible when you zoom in to a scale beyond 1:25,000.

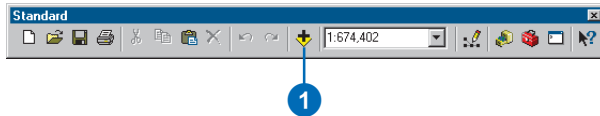
- Check the box next to the base_roads layer in the table of contents.



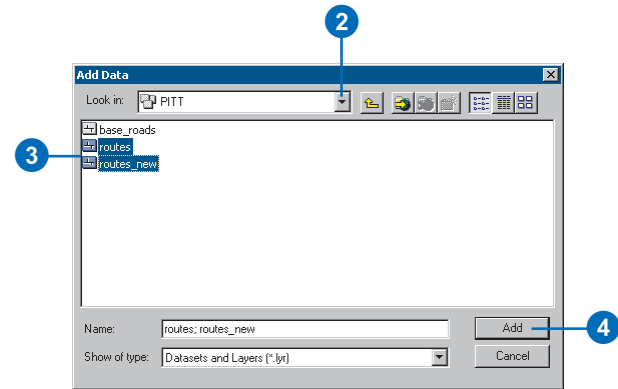
You will now see all of the roads in Pitt County. This includes roads not maintained by the highway authority. The roads maintained by the highway authority were written to the routes feature class.

Adding route data to your map

- Click the Add Data button.



- Click the Look in dropdown arrow and navigate to your \MyLR folder. Double-click PITT.mdb and double-click the PITT feature dataset.
- Press the Ctrl key and select both the routes and routes_new feature classes.
- Click Add.

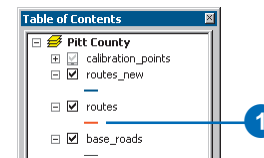


You will see the two new layers in the table of contents and also displayed in the ArcMap window.

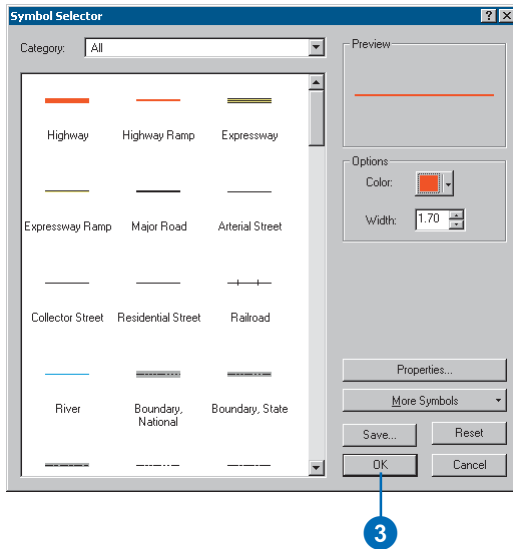
Changing the display symbol

The colors and symbols in which ArcMap chose to display the routes layer might make it difficult to see where the route features are located. It is easy to change the colors and symbols used to display features in ArcMap.

- Click the line symbol in the table of contents for the routes layer to display the Symbol Selector dialog box.



2. Scroll down until you find a symbol you like and click it.
3. Click OK. Your routes layer will be displayed with the symbol you chose.



4. Repeat steps 1 through 3 for the routes_new layer.
- You can also open the Symbol Selector dialog box by right-clicking the layer in the table of contents, clicking Properties, and clicking the Symbology tab. To simply change the color of a symbol, right-click the symbol in the table of contents to display the color palette, click any color or More Colors. For more information on changing display symbols, see *Using ArcMap*.
- You may have to click and drag the routes_new layer above routes in the table of contents to be able to see it.

Setting the Route Identifier field

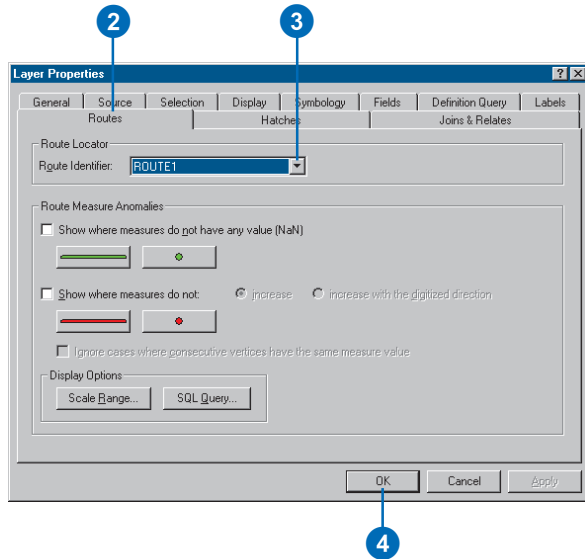
Whenever route data is added to a map, ArcMap knows to expose some additional layer properties. One of these properties is the Route Identifier field. The contents of this field uniquely identify each route.

Setting the Route Identifier field is not required. Doing so, however, reduces the number of steps required to use many of the ArcMap Linear Referencing dialog boxes, tools, and wizards.

1. Right-click the routes layer in the table of contents and click Properties.



2. Click the Routes tab.
3. Click the Route Identifier dropdown arrow and click ROUTE1.
4. Click OK.



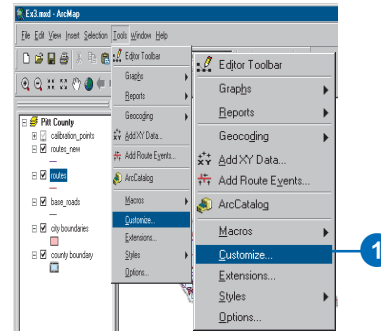
5. Repeat steps 1 through 4 for the routes_new layer.

Adding the Identify Route Locations tool

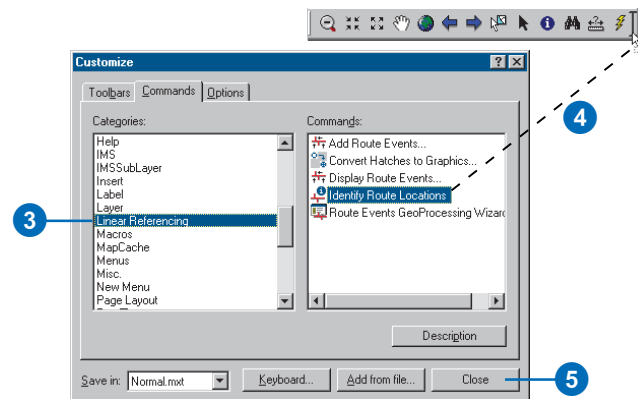
ArcMap gives you the ability to point to a route in a map and find the route identifier along with the measure value at that location. In this part of the exercise, you will use the Identify Route Locations tool to inspect the measures on the routes you created in Exercise 2.

The Identify Route Locations tool does not appear on any toolbar by default. You will have to add it to one.

1. Click Tools and click Customize.
2. Click the Commands tab.



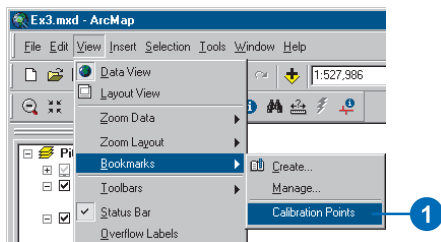
3. Click Linear Referencing in the Categories list.
4. Drag and drop the Identify Route Locations tool to the toolbar of your choice, such as the Tools toolbar.
5. Click Close.



Identifying route locations

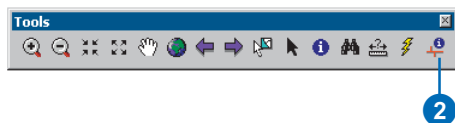
In ArcMap, a bookmark is a saved map location. A bookmark containing some of the calibration points used in Exercise 2 to recalibrate the routes has been created for you.

1. Click View, point to Bookmarks, and click Calibration Points.



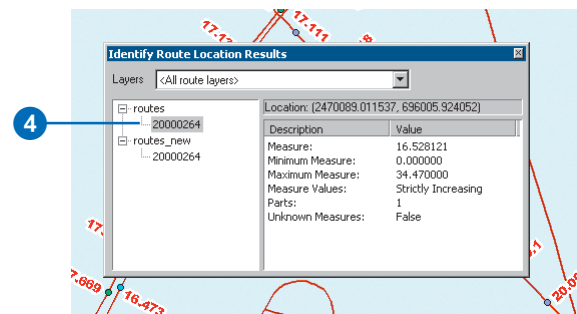
When ArcMap moves to the saved location, the calibration points appear with labels that represent the measure values for each point. The reason they appear when the bookmark has been used is because scale suppression was set on the layer. For more information on scale suppression, see *Using ArcMap*.

2. Click the Identify Route Locations button.



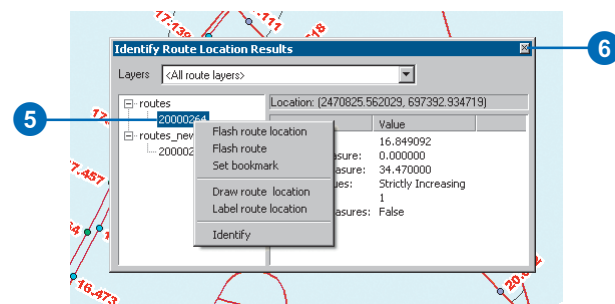
3. Move the mouse pointer over one of the calibration points and click. Route locations from both the routes and routes_new layers will be identified.

4. Click the route node for each of the route layers.

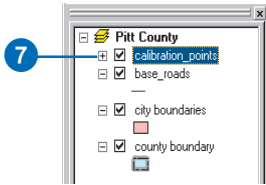


The numeric value listed for each of these nodes corresponds to the value stored in the Route Identifier field, which you set in a previous section of this exercise. Note that the measure value for the two routes differs. Note further that the measure value for the routes_new layer corresponds closely to the measure value of the calibration point you clicked—the closer you are to a calibration point, the closer the measure will be.

5. Right-click the route node for one of the layers and explore the context choices available to you.
6. Close the Identify Route Location Results window.



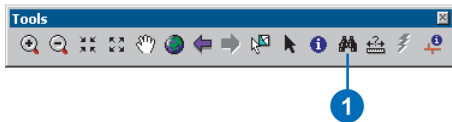
- Uncheck the check box for the calibration_points layer in the table of contents to make it not visible. It will not be used any further in this exercise.



Finding route locations

In many linear referencing applications, you will discover that you will often need to find a location along a route. For example, you may need to find where an accident occurred along a highway. On a paper map, it is hard to find a route location. This is because route measures are typically not shown. In ArcMap, finding a route location is made easy.

- Click the Find button on the ArcMap Tools toolbar.



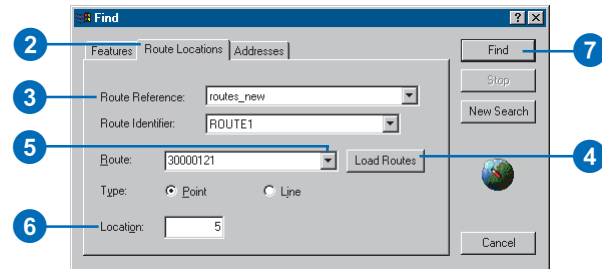
- Click the Route Locations tab to open the Find dialog box.
- Click the Route Reference dropdown arrow and click routes_new.

Notice that the field listed in the Route Identifier dropdown arrow corresponds to the Route Identifier field you set previously in this exercise.

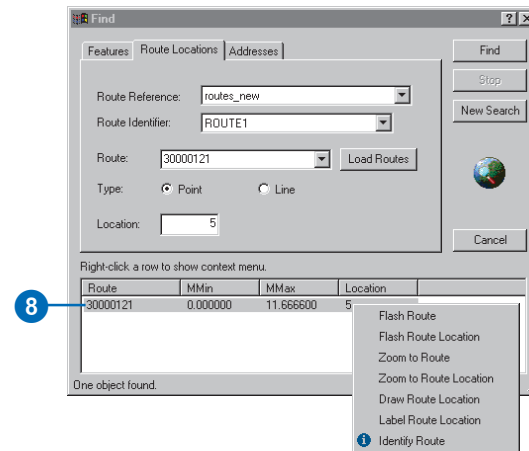
- Click Load Routes.

- Click the Route dropdown arrow and select 30000121.
This number is often a combination of many numeric fields and is meant to have no political, social, or economic meaning, so that it will not change over time.

- Type “5” in the Location text box.
- Click Find.



- Right-click the route location that was found and explore the context choices available to you.

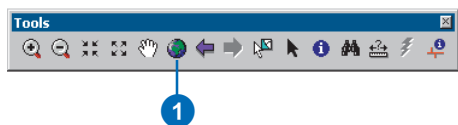


- Close the Find dialog box.

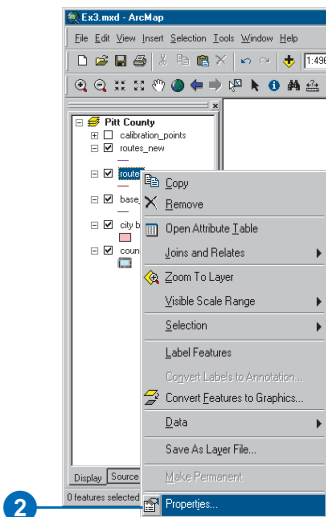
Displaying route measure anomalies

In most linear referencing applications, route measure values are expected to follow a set of rules. For example, you might expect that route measures always increase over the course of a route. ArcMap has the ability to show you where route measures do not adhere to the behavior you expect. These are known as *route measure anomalies*.

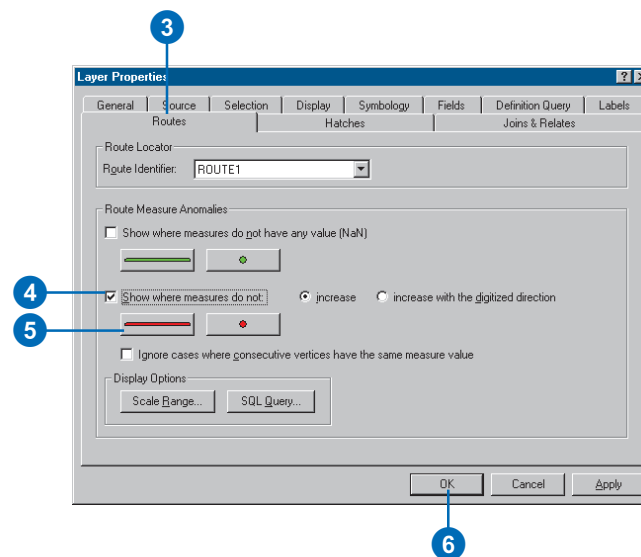
1. Click the Full Extent button on the ArcMap Tools toolbar.



2. Right-click the routes layer in the table of contents and click Properties.



3. Click the Routes tab.
4. Check Show where measures do not increase.
5. Click the Line Symbol button and select a line symbol you like. Do the same for the marker symbol.
6. Click OK.



Remember that the routes feature class was created from the base_roads feature class in Exercise 2. There are a few digitizing and attribute errors that caused the measure anomalies to exist in the routes feature class. Route measure anomalies can be fixed with ArcMap route editing tools. For more information on route editing tools, see Chapter 6, 'Editing routes'.

Exercise 4: Displaying and querying route events

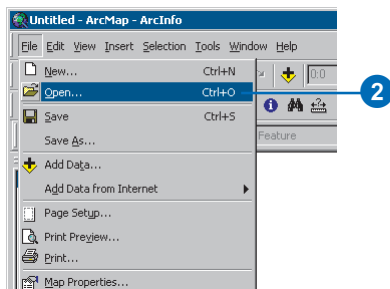
In this exercise, you will create a new event table that represents where injury accidents occurred along sections of poor-quality pavement. To do this, you will first use the Add Route Events dialog box to display the accident location and pavement quality event data on your map. You will then use the Select By Attributes dialog box to select the injury accidents and poor-quality pavement locations. You will use the Overlay Route Events tool to create a new event table whose records represent where injury accidents occurred along poor-quality pavement. Finally, you will add these events to the ArcMap display.

If you have not completed Exercise 2, open ArcCatalog. Within the Contents, delete PITT.mdb in your \MyLR folder and rename PITT_Results.mdb to PITT.mdb.

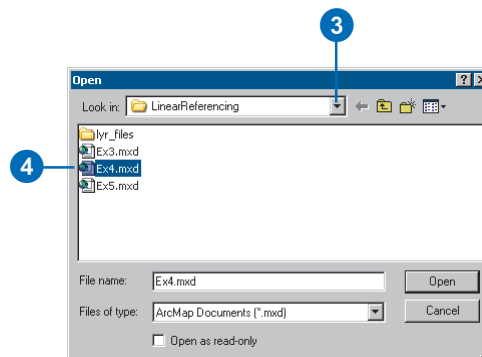
Opening an existing map document

To begin this exercise, you will start ArcMap and open an existing document.

1. Double-click a shortcut installed on your desktop or use the Programs list in your Start menu to start ArcMap.
2. Click File and click Open.



3. Click the Look in dropdown arrow in the Open dialog box and navigate to the location where you created the \MyLR folder.
4. Double-click Ex4.mxd. ArcMap opens the map.



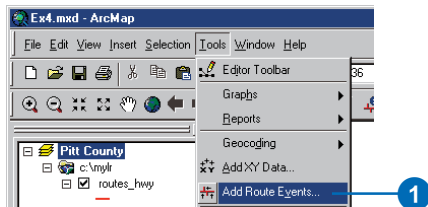
This map contains the following layers in a data frame called Pitt County:

routes_hwy	Shapefile copy of routes_new feature class you created in Exercise 2
county boundary	Pitt County boundary
accident	Point event table storing accident information
pavement	Line event table storing pavement information
base_roads	All of the roads in Pitt County

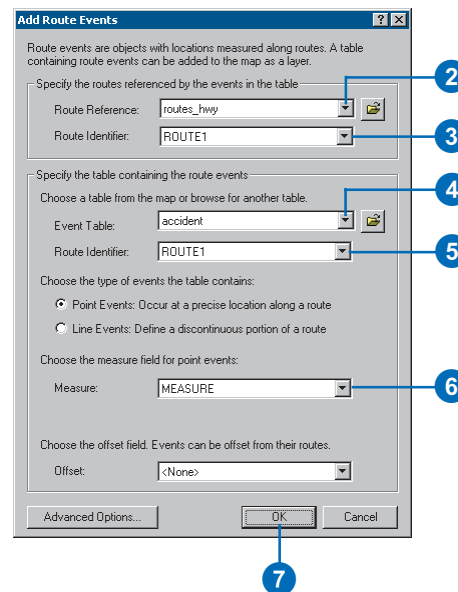
Displaying point events on your map

The accident table is a point event table. Point events occur at a precise point location along a route. In this section of the exercise, you will display the accident event data as a layer.

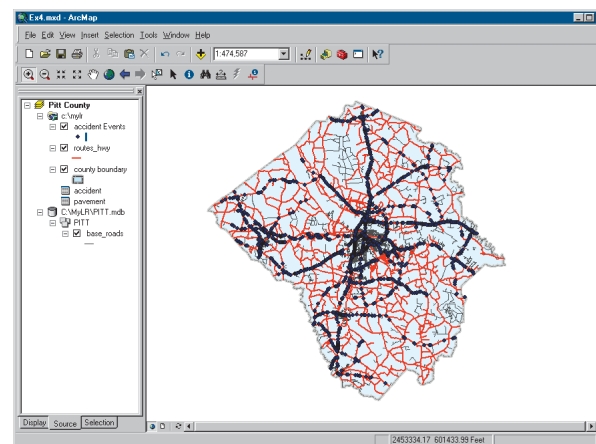
1. Click Tools and click Add Route Events.



2. Click the Route Reference dropdown arrow and click routes_hwy.
3. Click the Route Identifier dropdown arrow and click ROUTE1.
4. Click the Event Table dropdown arrow and click accident.
5. Click the Route Identifier dropdown arrow and click ROUTE1.
6. Click the Measure dropdown arrow and click MEASURE.
7. Click OK.



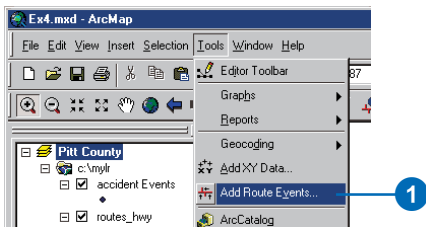
A new layer—accident Events—has been added to your map.



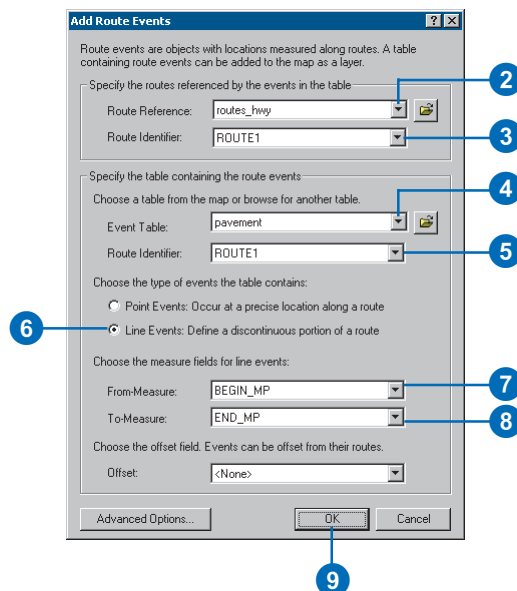
Displaying line events on your map

The pavement table is a line event table. Line events differ from point events in that they have two measure fields that define a portion of a route. The procedure for adding line events to your map is almost the same as adding point events.

1. Click Tools and click Add Route Events.



2. Click the Route Reference dropdown arrow and click routes_hwy.
3. Click the Route Identifier dropdown arrow and click ROUTE1.
4. Click the Event Table dropdown arrow and click pavement.
5. Click the Route Identifier dropdown arrow and click ROUTE1.
6. Click Line Events.
7. Click the From-Measure dropdown arrow and click BEGIN_MP.
8. Click the To-Measure dropdown arrow and click END_MP.
9. Click OK.



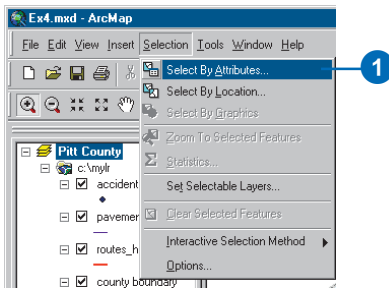
A new layer—pavement Events—has been added to your map.

You may have to use the zoom tool to zoom in on the map to see the pavement Events, or you could click and move the pavement Events layer to the top of the layer list in the table of contents.

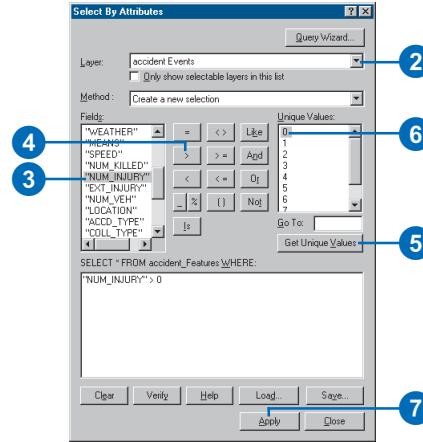
Querying events

Layers based on an event table can be queried in many ways. They can be identified by clicking them, they can be selected by dragging a box or clicking them on the map, they can be selected by clicking them in an attribute table, and they can be selected using a Structured Query Language (SQL) expression. You will use the Select By Attributes dialog box to input expressions to select the event records needed for this exercise. Specifically, you will select injury accidents and poor quality pavement.

1. Click Selection and click Select By Attributes.

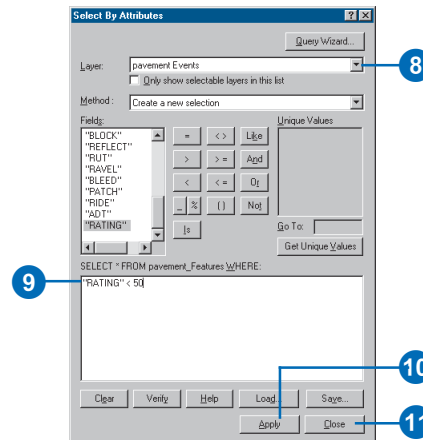


2. Click the Layer dropdown arrow and click accident Events.
3. Scroll down and double-click NUM_INJURY in the Fields list.
4. Click the greater than operator (>).
5. Click Get Unique Values.
6. Double-click 0 in the Unique Values list.
"NUM_INJURY" > 0 should be the expression appearing in the text box.
7. Click Apply.



You will see a number of the features in the accident Events layer selected in the ArcMap display window.

8. Click the Layer dropdown arrow and click pavement Events in the Select By Attributes dialog box.
9. Type the following in the text box: "RATING" < 50
10. Click Apply.
11. Click Close.

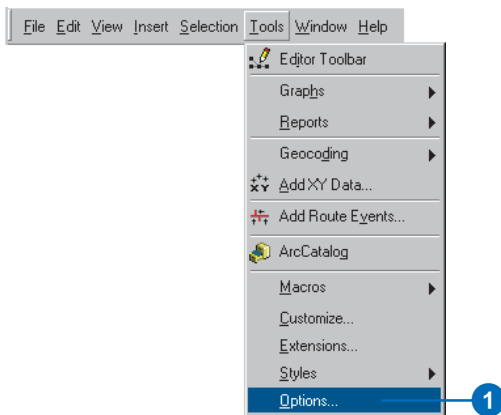


Now both the accident and pavement events are selected on your map. To see this more clearly, you may want to uncheck and check the accident Events and pavement Events layers in the table of contents.

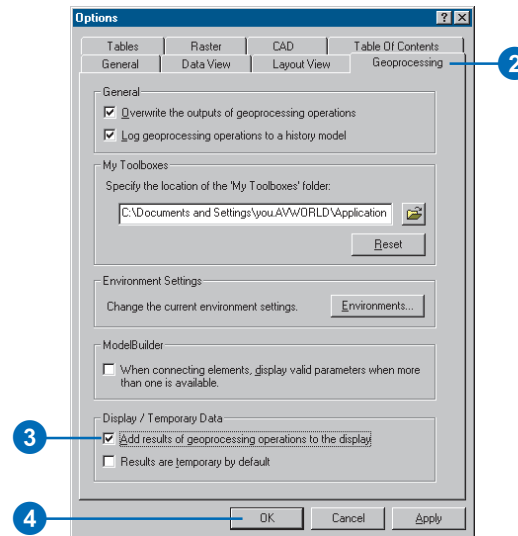
In the next section of this exercise, you will use the Overlay Route Events tool in ArcToolbox to intersect the two event layers. The result will be a table that contains the injury accidents that happened on poor-quality pavement. All attributes from both inputs are maintained. First, however, you need to be sure that your geoprocessing results are automatically added to your display.

Setting geoprocessing results to display automatically

1. Click Tools and click Options.



2. Click the Geoprocessing tab.
3. Check Add results of geoprocessing operations to the display.
4. Click OK.

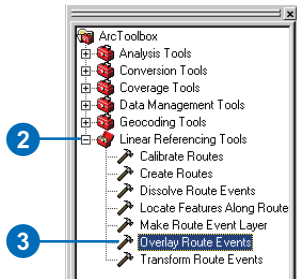


Intersecting event layers

1. Click the Show/Hide ArcToolbox button.

This opens the ArcToolbox window. You can dock and undock this window or move this window around the ArcMap window.

- Expand the Linear Referencing Tools.
- Right-click the Overlay Route Events tool and click Open.



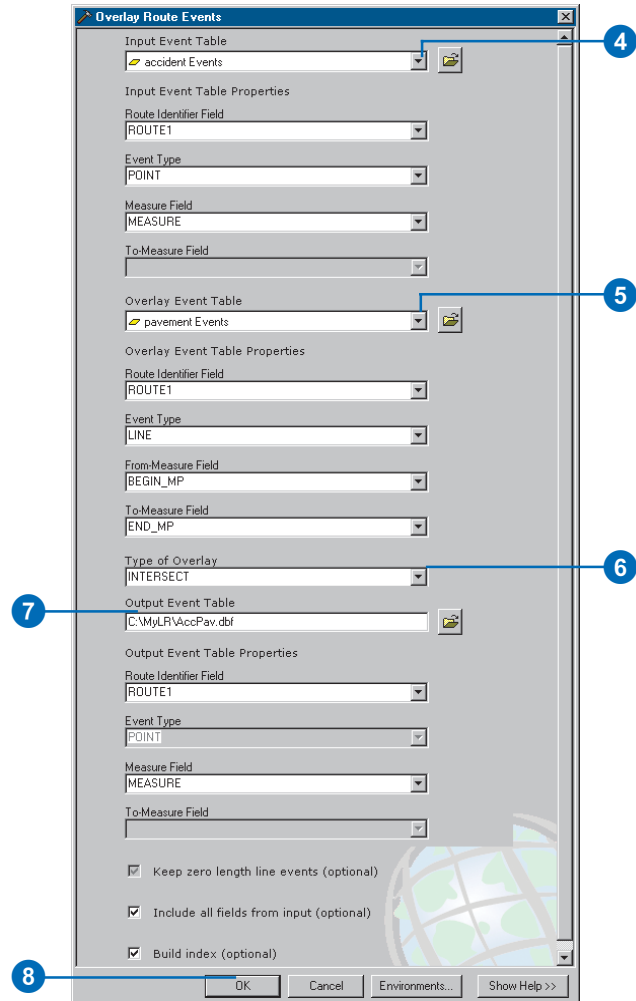
- Click the Input Event Table dropdown arrow and click the accident Events layer.

NOTE: Because you selected an event layer, the Route Identifier Field, Event Type, and Measure Fields were set automatically. If you had selected an event table, you would be responsible for setting these parameters.

- Click the Overlay Event Table dropdown arrow and click the pavement Events layer.
- Click the Type of Overlay dropdown arrow and click INTERSECT. This will allow you to find the intersecting event layers.
- Type “C:\MyLR\AccPav.dbf” for the value of the Output Event Table parameter.

You’ll keep the remaining defaults.

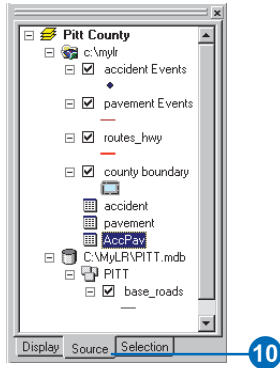
- Click OK.



The tool’s progress dialog box opens as the tool runs.

- Click Close on the tool’s progress dialog box when the process is finished.

- The AccPav.dbf table is added to the ArcMap session. If you cannot see it in the table of contents, click the Source tab.

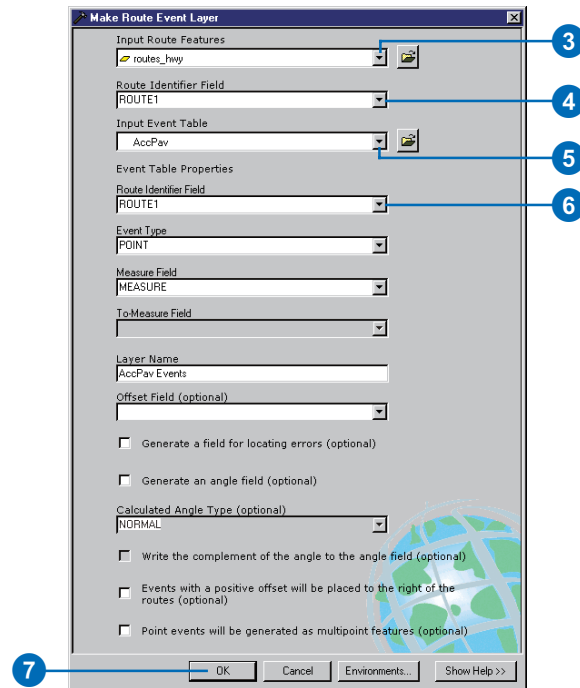


Displaying the intersected event results

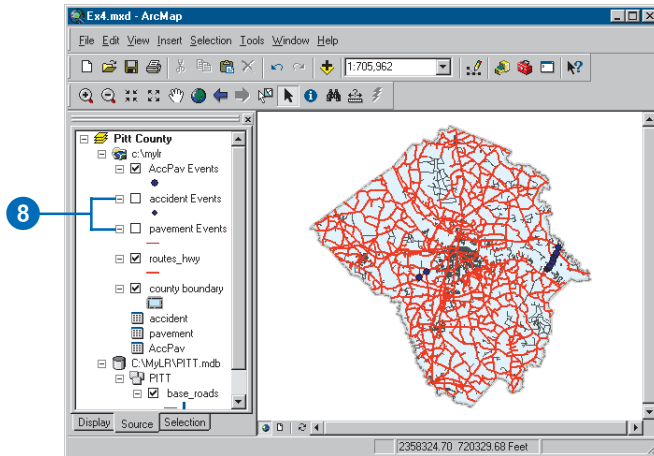
At the beginning of this exercise, you used the Add Route Events dialog box (from the Main menu) to display the accident and pavement condition information as layers in your map. Another way to do this is to use the Make Route Event Layer tool (from ArcToolbox). When called from ArcCatalog, this tool creates a temporary, in-memory layer similar to the one you created in Exercise 2. When executed in ArcMap, the in-memory layer is added to the display.

- Expand the Linear Referencing Tools in ArcToolbox.
- Right-click the Make Route Event Layer tool and click Open.
- Click the Input Route Features dropdown arrow and click the routes_hwy layer.

- Click the Route Identifier Field dropdown arrow and click ROUTE1.
- Click the Input Event Table dropdown arrow and click AccPav.
- Click the Route Identifier Field dropdown arrow for the event table and click ROUTE1.
- Click OK.



The AccPav Events layer is added to the table of contents.



8. Uncheck the accident Events and pavement Events layers in the table of contents.

You will now see only the injury events that occurred along poor quality pavement. Each of these new events has all the attributes from both the accident and pavement tables.

For more information on the display and query of events or the spatial analysis of events, see Chapter 5, 'Displaying and querying routes and events', and Chapter 7, 'Creating and editing event data'.

Exercise 5: Editing routes

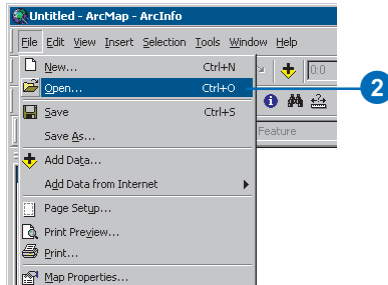
There are a number of tools in ArcMap that make the interactive creation and editing of route measures easy. In this exercise, you will create a new route from a selected set of linear features and set its identifier. You will then convert the measures of this newly created route from feet to miles. Last, you will recalibrate the route using known measure values at specific locations on your map.

If you have not completed Exercise 2, open ArcCatalog. Within the Contents, delete PITT.mdb in your \MyLR folder and rename PITT_Results.mdb to PITT.mdb.

Opening an existing map document

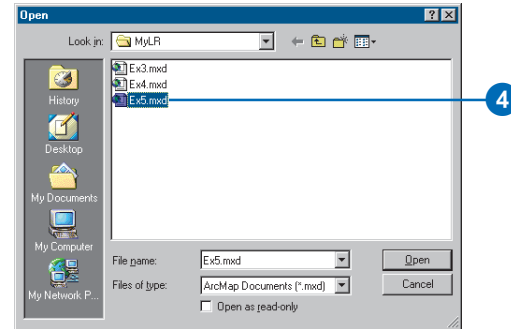
In order to use this exercise, you must start ArcMap.

1. Double-click a shortcut installed on your desktop or use the Programs list in your Start menu to start ArcMap.
2. Click File and click Open.



3. Click the Look in dropdown arrow in the Open dialog box and navigate to the folder where you installed the data for this tutorial.

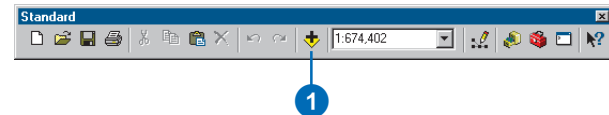
4. Double-click Ex5.mxd. ArcMap opens the map.



Adding route data to your map

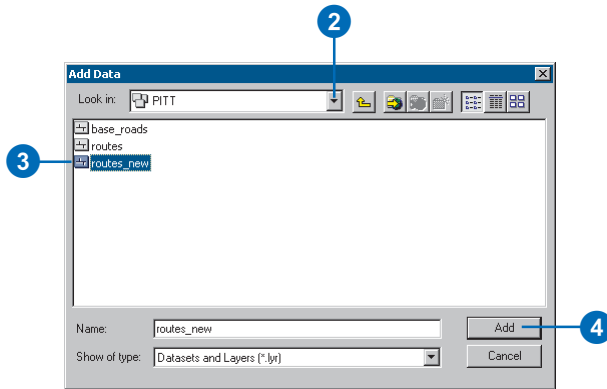
You will use one of the route feature classes you created in Exercise 2 to complete this exercise.

1. Click the Add Data button.



ArcInfo and ArcEditor

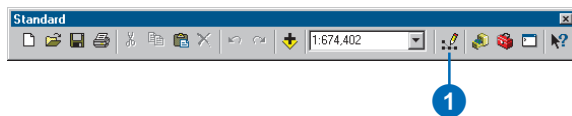
2. Click the Look in dropdown arrow and navigate to your \MyLR folder. Double-click PITT.mdb and double-click the PITT feature dataset.
3. Click the routes_new feature class.
4. Click Add.



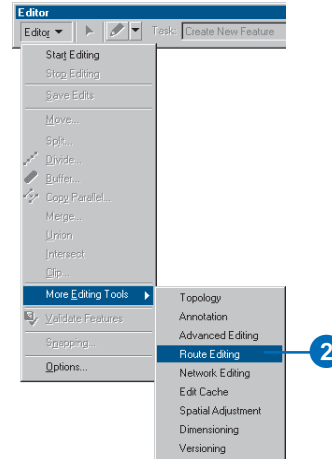
Adding the toolbars, editing, and setting the target feature class

The toolbars necessary to complete this exercise might not be visible.

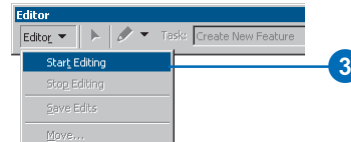
1. Click the Editor Toolbar button to add the Editor toolbar to ArcMap.



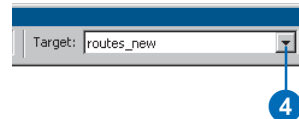
2. Click the Editor menu, point to More Editing Tools, and click Route Editing.



3. Click the Editor menu and click Start Editing.



4. Click the Target dropdown arrow on the Editor toolbar, and click routes_new.

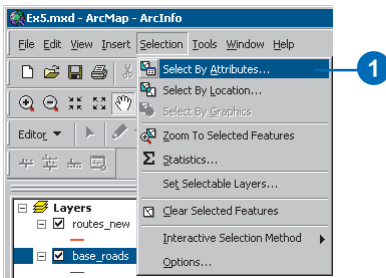


Making a route from selected features

The highway authority has been informed that it will now be responsible for maintaining a road that it previously had not been maintaining. It is necessary, therefore, to select the appropriate features from the base_roads feature class and make a route in the routes_new feature class out of them.

The Make Route command creates a new route in the target feature class by merging a selected set of line features and setting the measure values. The selected line features do not need to be from the target feature class.

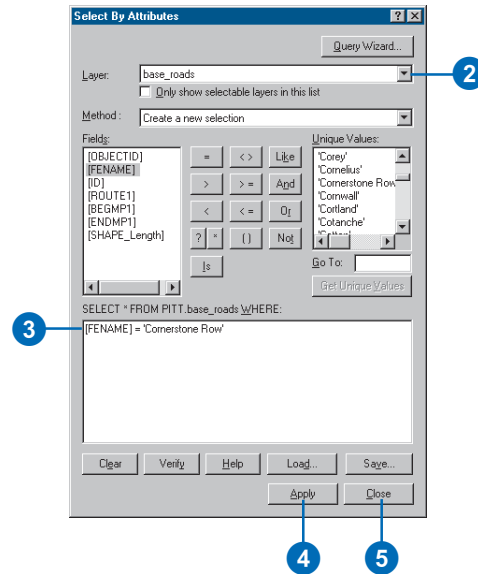
1. Click Selection and click Select By Attributes.



2. Click the Layer dropdown arrow and click base_roads.
3. Type the following in the text box:
[FENAME] = 'Cornerstone Row'

If you're clicking in the field boxes to build the expression, you may need to click Complete List, under Unique sample values.

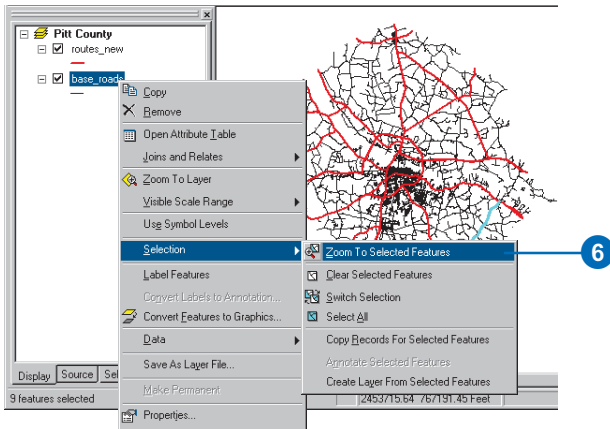
4. Click Apply.
5. Click Close.



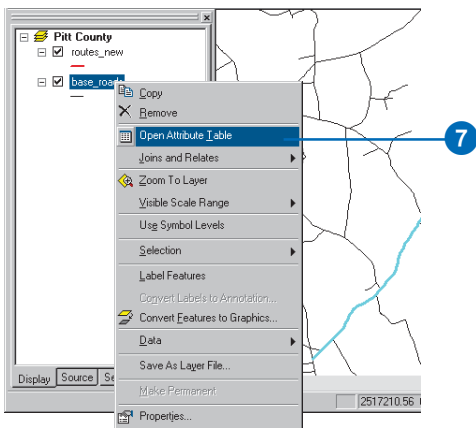
Nine features from the base_roads feature class are now selected.

ArcInfo and ArcEditor

- Right-click the base_roads layer in the table of contents, point to Selection, and click Zoom To Selected Features.



- Right-click the base_roads feature class layer and click Open Attribute Table.



- Click Selected to show only the selected records. You can also see the total number of selected records shown along the bottom of this window.

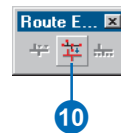
A screenshot of the 'Selected Attributes of base_roads' window. The window displays a table with the following data:

OBJECTID	Shape*	FENAME	ID	Shape_Leng
703	Polyline	Comerstone Row	1143	6953.934987
1715	Polyline	Comerstone Row	1310	608.928734
1752	Polyline	Comerstone Row	1368	5282.339376
1757	Polyline	Comerstone Row	1373	463.073115
1793	Polyline	Comerstone Row	1409	1088.322312
1799	Polyline	Comerstone Row	1415	953.611706
6782	Polyline	Comerstone Row	7365	4953.325598
7443	Polyline	Comerstone Row	7434	2326.885913
7444	Polyline	Comerstone Row	7435	1443.090693

At the bottom of the window, there is a status bar that reads 'Record: 1 | 1 | Show: All Selected Records (9 out of *2000 Selected.)'. A blue circle with the number 8 points to the 'Selected' radio button in the 'Show' section.

- Close the Attributes table.

- Click the Make Route button on the Route Editing toolbar.



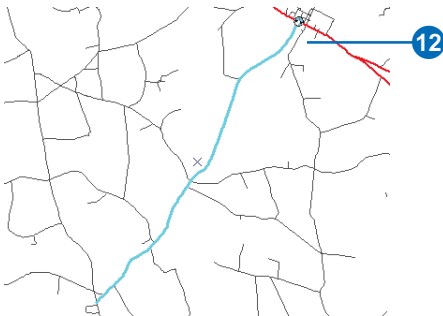
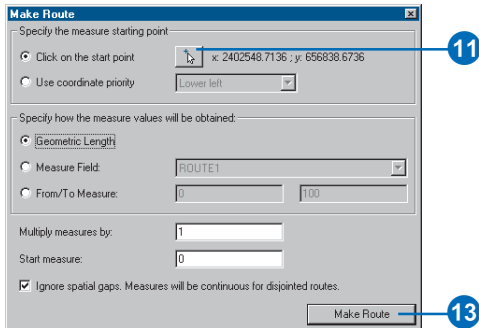
11. Click the Start Point button.

The Make Route dialog box changes and lets you know you need to pick a route starting point.

12. Click the map near the upper-right corner of the selected set of features. This is where the output route's measures will begin.

The program tries to assist you by circling the endpoint it will select. As you move your mouse along the route, this point can change. This is useful because you do not need to select the exact spot on the route; just click on the display when the correct location is circled.

13. Click Make Route on the Make Route dialog box.

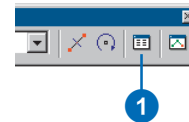


The new route will flash when it is being created. During the route creation process, the selected lines will be deselected, and the new route will be selected. This is so you can set the new route's attributes.

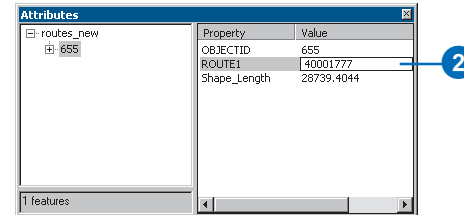
Setting the Route Identifier

Because the newly created route is selected, you can now set the route identifier. The route identifier uniquely identifies each route.

1. Click the Attributes button on the Editor toolbar.



2. Click the ROUTE1 Value and type "40001777".



3. Press Enter on your keyboard.

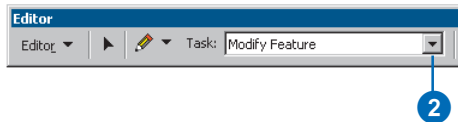
4. Close the Attributes dialog box.

ArcInfo and ArcEditor

Converting route measure units

When you created the new route, you accepted the default method for setting the route measures. This method accumulates the geometric length of the input line features and uses the length as the measure. Because the coordinate system of the feature class is State Plane Feet, the measures on the new route are in feet. However, the measures on all other routes in the feature class are in miles.

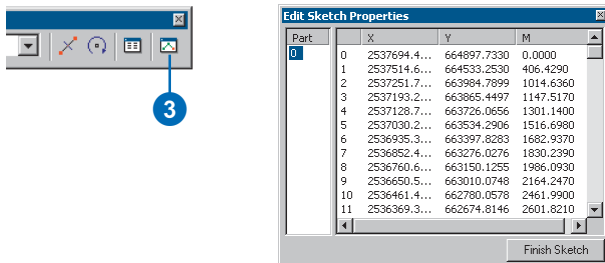
1. The newly created route should still be selected. If it is not, select it.
2. Click the Task dropdown arrow on the Editor toolbar and click Modify Feature.



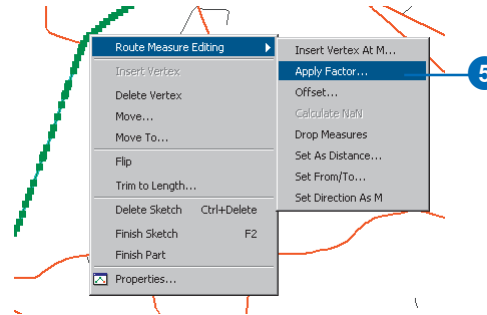
The selected feature will now be loaded into the edit sketch.

3. Click the Sketch Properties button.

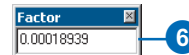
Note the size of the measure values (in column M).



4. Close the Edit Sketch Properties dialog box.
5. Right-click anywhere over the edit sketch (you know you are over the line when the mouse pointer changes), point to Route Measure Editing, and click Apply Factor.



6. Type "0.00018939" in the Factor text box and press Enter on the keyboard. This converts feet to miles.



At this point, you have only made changes to the edit sketch, not the route feature.

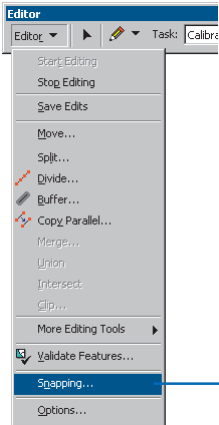
7. Press F2 to finish the edit sketch. Alternately, right-click anywhere over the edit sketch and click Finish Sketch.

Your route measures are now in miles. You can verify this by double-clicking the selected route to bring it into the edit sketch, right-clicking anywhere over the sketch, and clicking Properties. Note that this is an alternate way to perform Steps 2 and 3.

Recalibrating a route

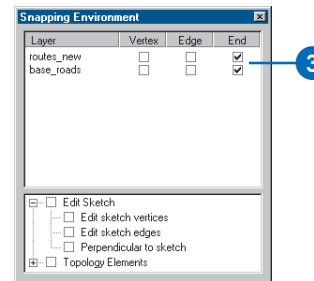
So far in this exercise, you have created a route and transformed its measures from feet to miles. Imagine that at some point the maintenance crew went out into the field and recorded the actual mileage for this new route. The mileage was captured every time the new route intersected with another route from the same feature class. In this section of the exercise, you will recalibrate the newly created route based on this mileage information.

1. The newly created route should still be selected. If it is not, select it.
2. Click the Editor menu and click Snapping.



This opens the Snapping Environment window, which is a dockable window.

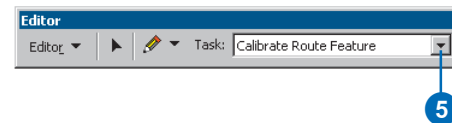
3. Check the End check box next to the routes_new and base_roads layers.



4. Close the Snapping Environment dialog box. It will not be used again in this exercise.

With the snapping environment set, you will be able to create calibration points that are snapped to the end vertex of the features in the routes_new layer, thereby ensuring accuracy of the route measures at the calibration points. Setting the snap environment, however, is not necessary for the Calibrate Route command to work.

5. Click the Task dropdown arrow and click Calibrate Route Feature.



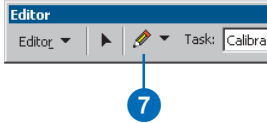
6. Click the Calibrate Route button on the Route Editing toolbar.



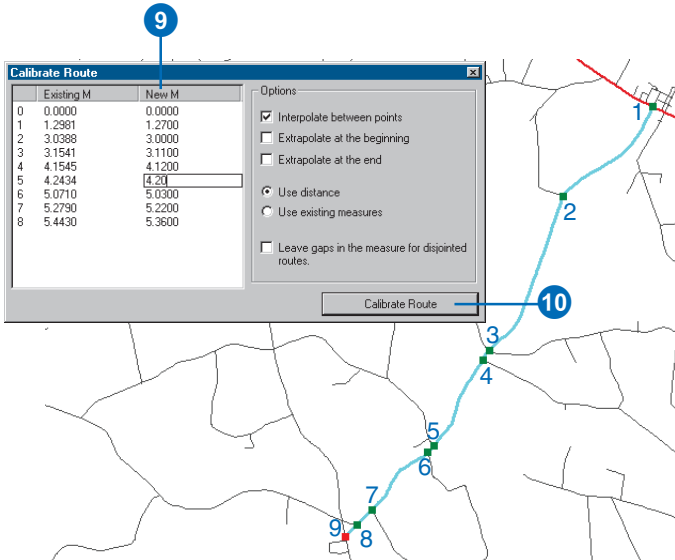
ArcInfo and ArcEditor

The Calibrate Route dialog box is now on the screen, but it is empty. Your next task is to digitize the calibration points.

7. With the Calibrate Route dialog box open, click the Sketch tool on the Editor toolbar.



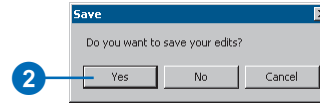
8. Click along the route at nine different places to create the calibration points. The locations of the calibration points are indicated in the graphic below.
9. Enter the New M values (see values in graphic below) for each calibration point by clicking each value in the column and typing the new value.
10. Click Calibrate Route.



Saving your edits

Once you have completed the steps in this exercise, you can choose to save or discard your edits by stopping the edit session.

1. Click the Editor menu and click Stop Editing.
2. Click Yes to save your edits.



In this exercise, you first learned how to create a route from a selected set of line features. Next, you converted the route measures from feet to miles. Last, you learned how to recalibrate a route using calibration points you digitized on the map.

For more details about the route editing tools outlined here or for information on tools not discussed in this chapter, see Chapter 6, 'Editing routes'.