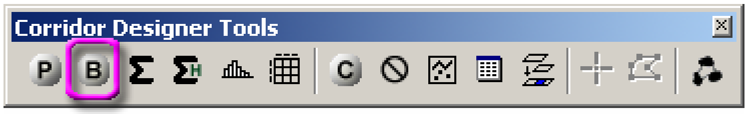
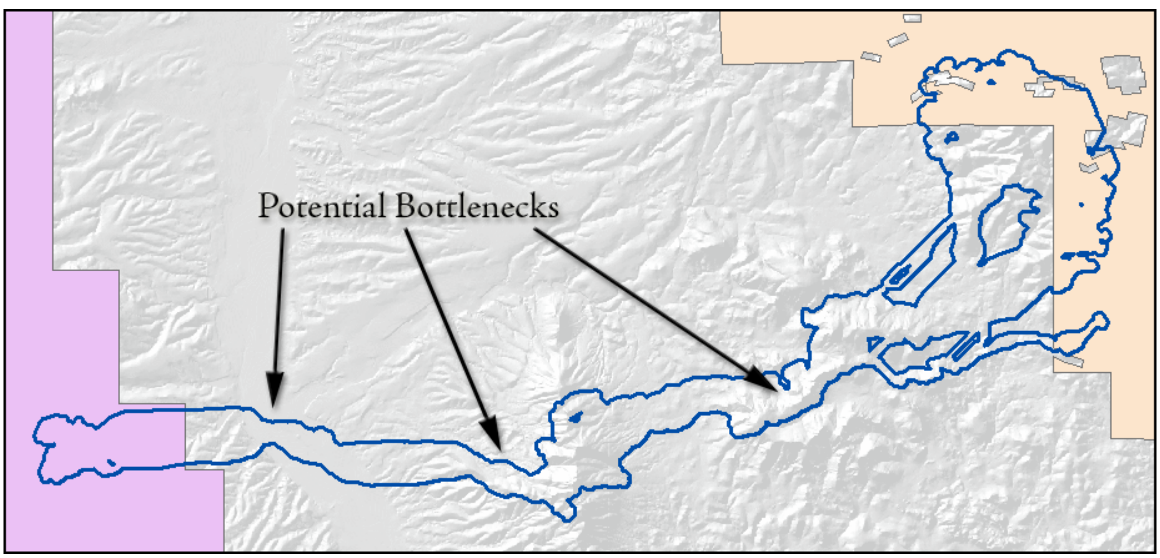




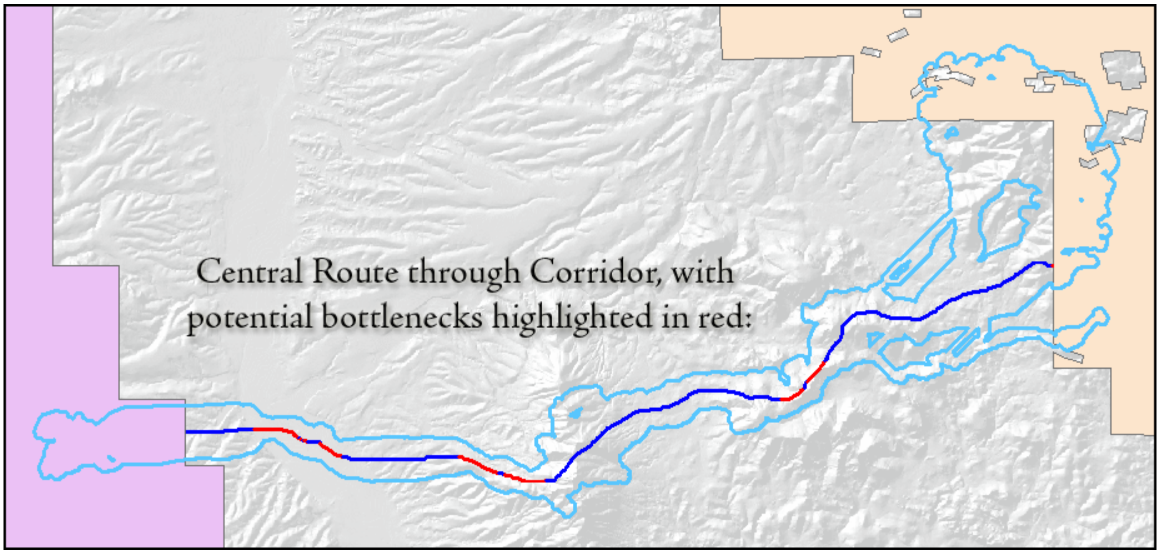

---

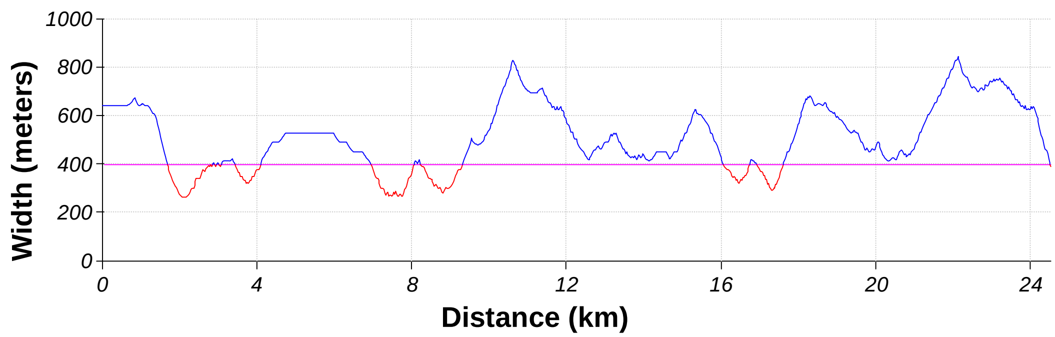
## Bottleneck Analysis:

For species that are sensitive to development or edge effects, or who require some level of isolation from disturbance, corridors may not be usable if they are too narrow. A narrow spot in the corridor is considered a bottleneck and severe bottlenecks may render the corridor useless for some species. Possibly a bottleneck may be overcome if it is not too long and not too narrow, and therefore the task is to identify both the presence and the length of potential bottlenecks.




This tool analyzes a corridor for potential bottlenecks by identifying a route that connects both habitat blocks and which extends through the center of the widest possible sections of the corridor polygon. It then calculates the width of the corridor (defined as twice the distance to the closest point on the corridor boundary) at regular intervals along that route and generates a graph illustrating the width along the entire route. This tool also allows you to set a threshold corridor width and identify all portions of the corridor that fall below that threshold.



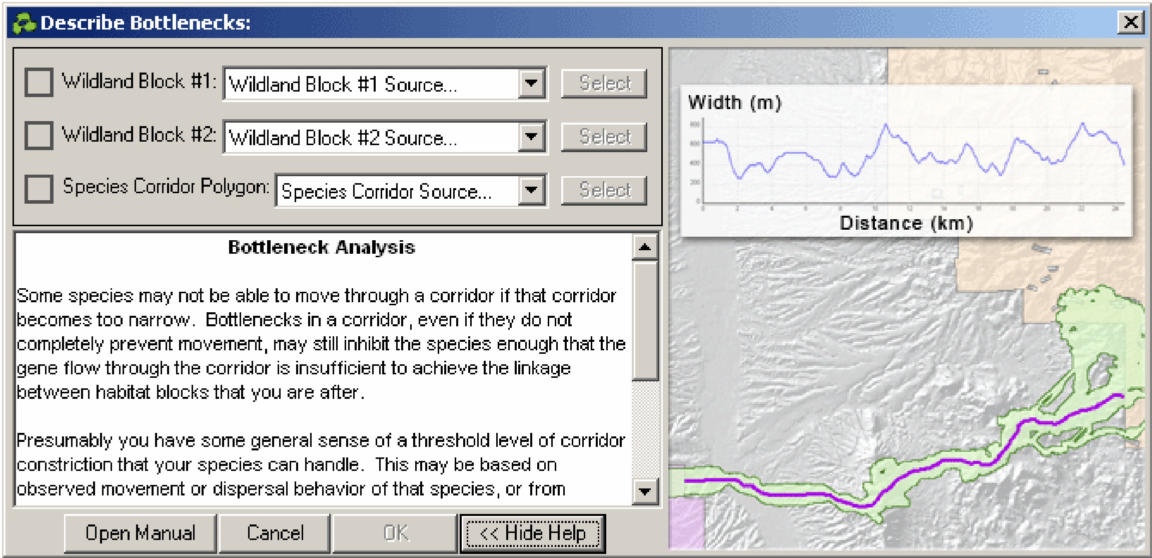

You can easily examine different threshold widths. In this example, it might be appropriate to check field conditions in the 6 bottlenecked regions. If some of these areas are not constrained by "hard" edges (e.g., a body of open water, an urban development), you could widen the corridor at that narrow spot. This tool will likely take about a minute per analysis so you can try different alternative scenarios without too much pain.

**NOTE:** This tool works much better if the corridor is projected into a foot- or meter-based coordinate system. The tool will still work with geographic data, but the threshold distances will be much harder to interpret.

### USING THE BOTTLENECK TOOL:

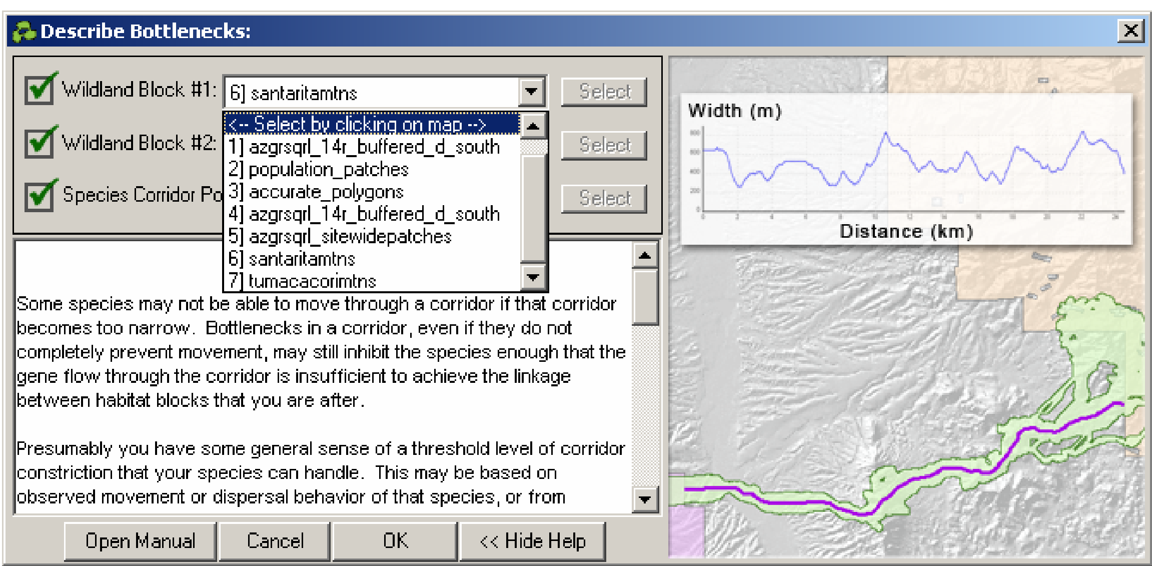
As with the Patch Analysis example, we will assume that we have previously generated a corridor for Arizona ground squirrels that connects the Santa Rita Mountains to the Tumacacori Mountains in southern Arizona (see illustration above).

Click the  button to open the "Describe Bottlenecks" dialog:




Select the polygons that correspond to your corridor and habitat blocks. You may only select a single polygon for each object, although that polygon may be a multi-part polygon. If you have a polygon layer containing only a single feature, then you may simply select that layer from the list in the dropdown box. If you wish to select a single polygon from an existing layer, or if you wish to select or draw a graphic polygon, then click the second item in the drop-down list "Select by clicking on map":

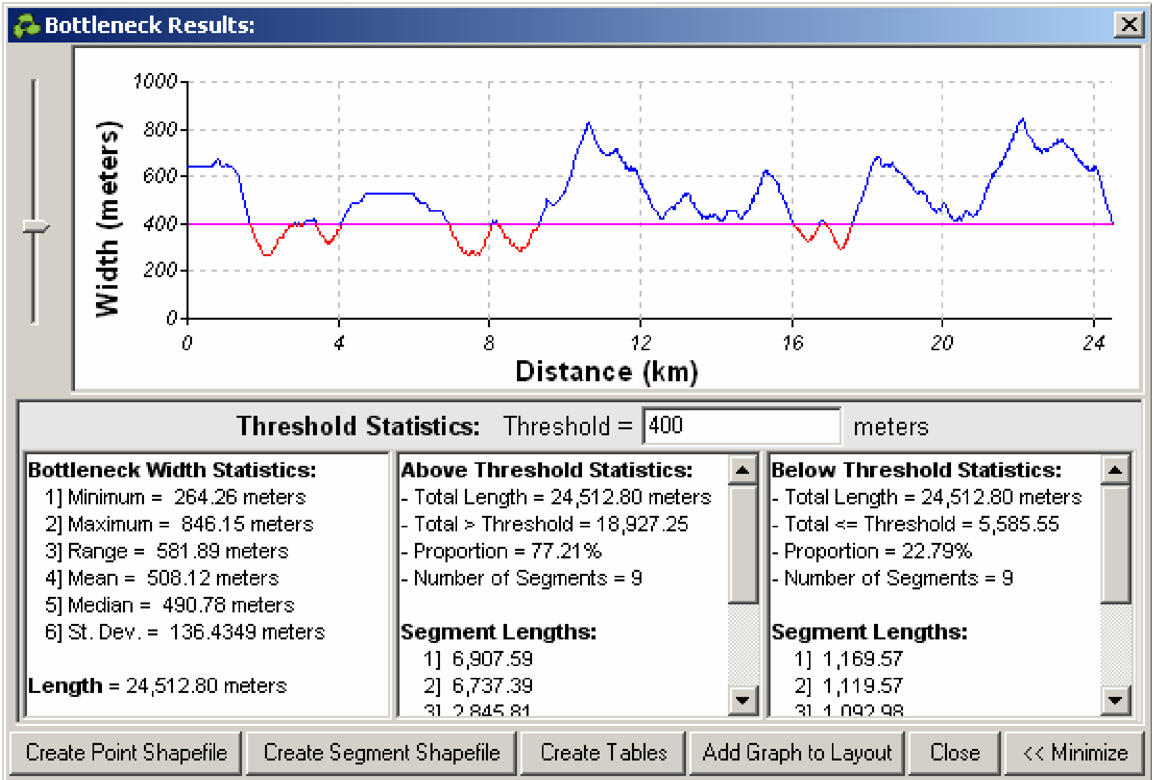
**NOTE:** As with the Patch tool, this tool will not let you use several separate polygons as a single "wildland block" or "corridor" object. If you wish to use several polygons for this purpose, you will need to combine them into a single entity first. We have a separate stand-alone tool available which will do this function, available for free download at [http://www.jennessent.com/arcgis/shapes_graphics.htm](http://www.jennessent.com/arcgis/shapes_graphics.htm) (see especially the discussion of the "Combine Features" tool).




This will enable the "Select" button just to the right of the drop-down list. Click the "Select" button to open the "Selecting or Drawing Polygons" function (see Selecting or Drawing Polygons [p. 9] for details on this on using this tool).

After selecting your corridor and habitat block polygons, click ‘OK’ and wait for a minute or so. Upon completion, the tool will open up the “Bottleneck Results” dialog:

BOTTLENECK RESULTS DIALOG:



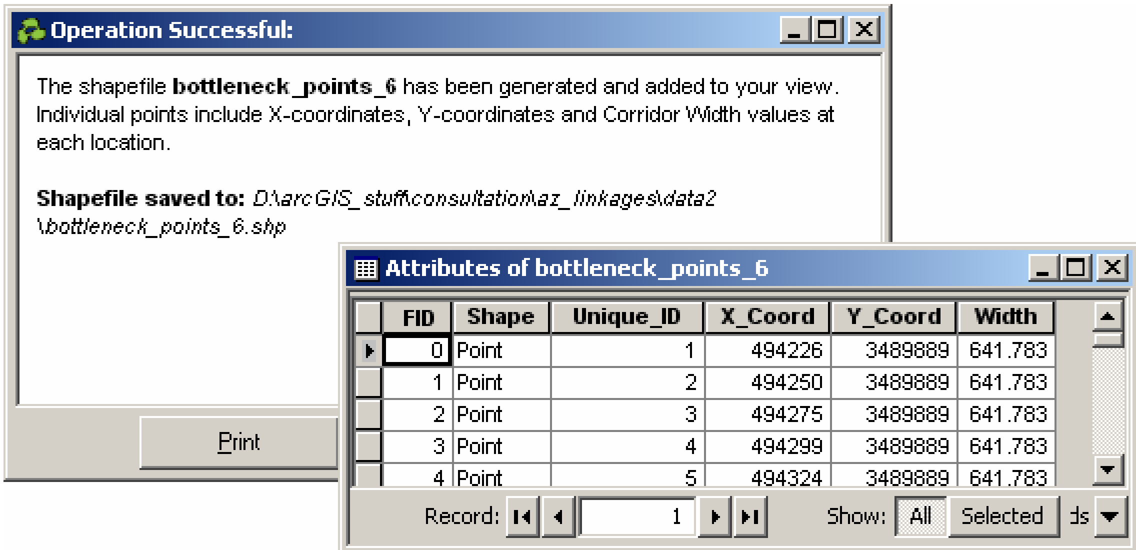

Note that the graph is linked to the map, so that the areas below the threshold are marked in red on both the graph and the map. The text boxes at the bottom of the dialog report detailed statistics on the amounts of the centerline route that lie above and below the threshold, including segment lengths sorted in decreasing order. For example, the illustration above shows the statistics for a threshold value of 400m. In this case, 23% of the corridor is narrower than 400m, and at least 3 stretches of below-threshold corridor sections are over 1km long. The narrowest point of the corridor is 264m and the average width along the best route is 508m. If this species is highly sensitive to bottlenecks, and if 400m is an absolute minimal requirement, then this corridor may not serve the species well.

ADJUSTING THE THRESHOLD: You may adjust the threshold 3 ways:

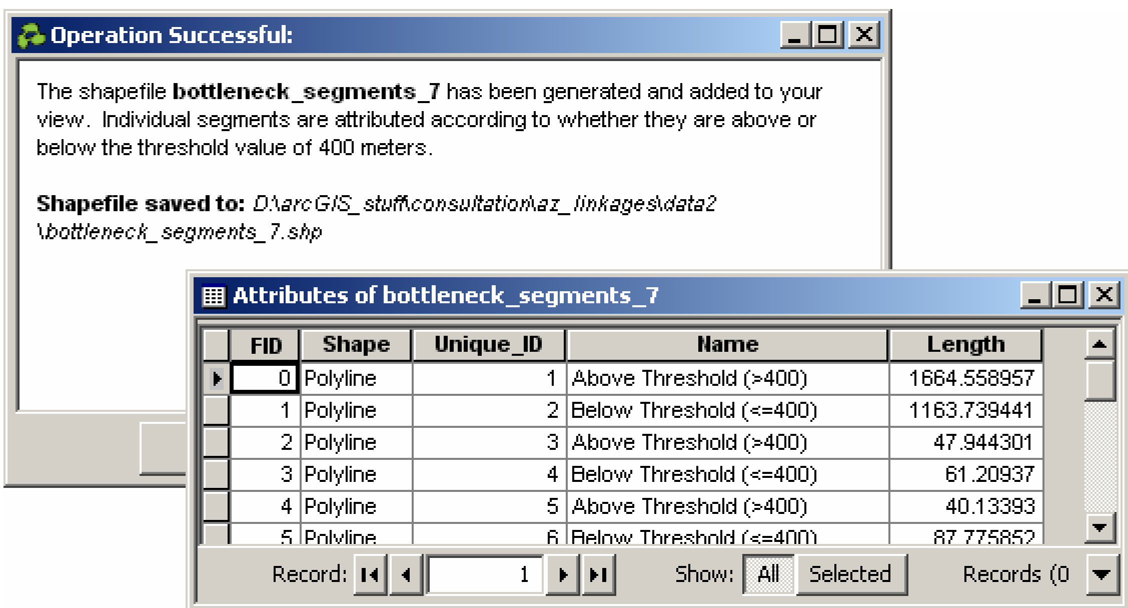
1) Type in an exact threshold value in the text box.
2) Click on the graph at the point you would like to reset the threshold.
3) Move the slider control in the upper left corner up and down.

SAVING THE CORRIDOR ROUTE: If you wish to save the centerline route for any reason, you have several options to do so:

1) *Point Shapefile:* The “Create Point Shapefile” function will generate approximately 1000 evenly-spaced points along the centerline route, with attribute values for Unique ID, X-coordinate, Y-coordinate and Corridor Width at that point. Upon completion, the function will open a report window and add the new shapefile to your map.




2) *Segment Shapefile:* The "Create Segment Shapefile" function will divide the route up into "Above Threshold" and "Below Threshold" segments and export them to a polyline shapefile. Segments will include attribute values indicating whether they are above or below the threshold, as well as the lengths of those segments.

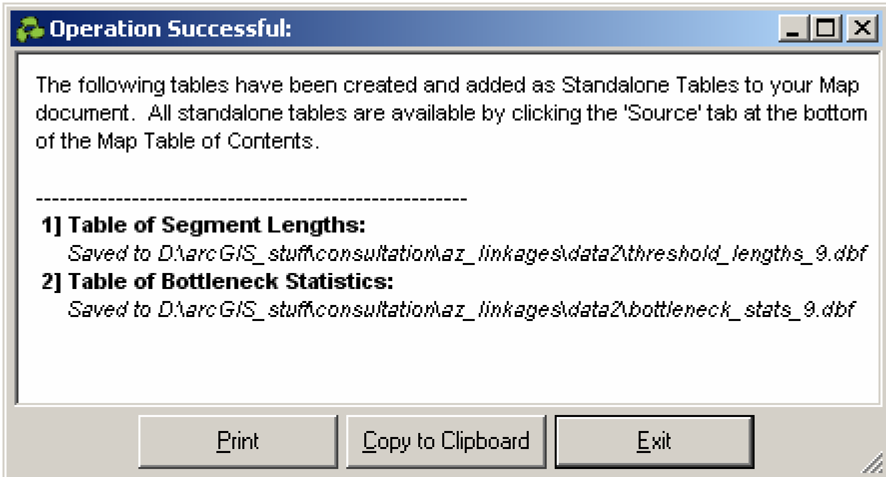


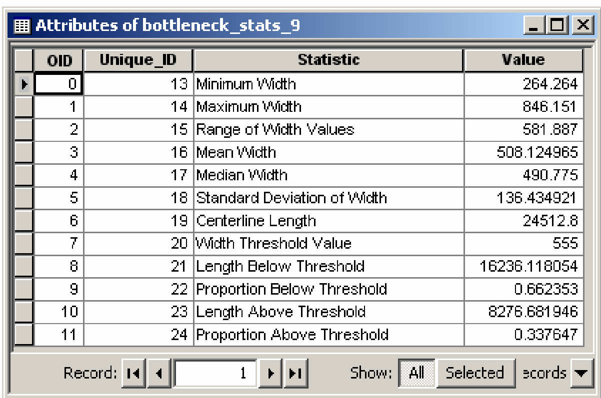

3) *Segment Shapefile:* You may also use the Corridor Designer "Create New Shapefile" function (see p. 13) to convert the graphic segments to a polyline shapefile.

GENERATING DBASE TABLES: The "Create Tables" button will generate 2 tables and add them as standalone tables to your map document. Remember that all standalone tables are available by clicking the "Source" tab at the bottom of the Map Table of Contents. The two tables are:

1) *Table of Segment Lengths:* Contains the threshold value, total length of the centerline route, and lengths of all segments above and below the threshold sorted in decreasing order. The dBASE table will be named "bottleneck_segments_#.dbf", where "#" is the lowest possible integer value that guarantees a unique filename.

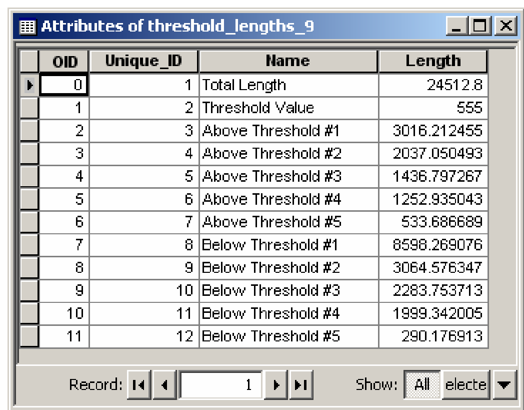
2) *Table of Bottleneck Stats:* Contains general descriptive statistics on the corridor width along the entire centerline route, as well as proportions and lengths of the centerline route above and below the current threshold value. This table will be named “bottleneck_stats_#.dbf”, where “#” is the lowest possible integer value that guarantees a unique filename.





Attributes of bottleneck_stats_9

| OID | Unique_ID | Statistic | Value |
|---|---|---|---|
| 0 | 13 | Minimum Width | 264.264 |
| 1 | 14 | Maximum Width | 846.151 |
| 2 | 15 | Range of Width Values | 581.887 |
| 3 | 16 | Mean Width | 508.124965 |
| 4 | 17 | Median Width | 490.775 |
| 5 | 18 | Standard Deviation of Width | 136.434921 |
| 6 | 19 | Centerline Length | 24512.8 |
| 7 | 20 | Width Threshold Value | 555 |
| 8 | 21 | Length Below Threshold | 16236.118054 |
| 9 | 22 | Proportion Below Threshold | 0.662353 |
| 10 | 23 | Length Above Threshold | 8276.681946 |
| 11 | 24 | Proportion Above Threshold | 0.337647 |

Record: 1 Show: All Selected ecords

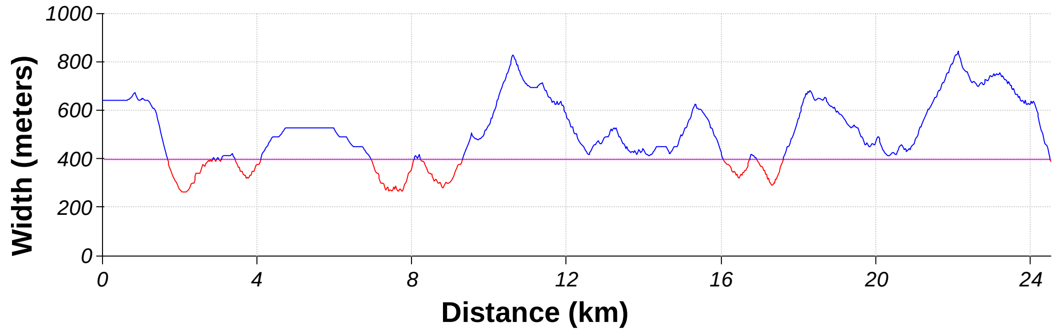

Attributes of threshold_lengths_9

| OID | Unique_ID | Name | Length |
|---|---|---|---|
| 0 | 1 | Total Length | 24512.8 |
| 1 | 2 | Threshold Value | 555 |
| 2 | 3 | Above Threshold #1 | 3016.212455 |
| 3 | 4 | Above Threshold #2 | 2037.050493 |
| 4 | 5 | Above Threshold #3 | 1436.797267 |
| 5 | 6 | Above Threshold #4 | 1252.935043 |
| 6 | 7 | Above Threshold #5 | 533.686689 |
| 7 | 8 | Below Threshold #1 | 8598.269076 |
| 8 | 9 | Below Threshold #2 | 3064.576347 |
| 9 | 10 | Below Threshold #3 | 2283.753713 |
| 10 | 11 | Below Threshold #4 | 1999.342005 |
| 11 | 12 | Below Threshold #5 | 290.176913 |

Record: 1 Show: All electe

ADD GRAPH TO LAYOUT: This function converts the graph in the “Bottleneck Results” dialog to a Windows Enhanced Metafile (*.emf) format and automatically adds it to your Map Layout. It then produces a report notifying you of where the file is, in case you also want to add the graph to other documents.

**NOTE:** One nice thing about the *.emf format is that Microsoft has attempted to make it some sort of standard, so there are at least a few other programs that recognize it. Not surprisingly, Microsoft Word documents handle *.emf images just fine and therefore they can easily be inserted in reports. For example, the author simply dragged-and-dropped the image file “bottleneck_stats_9.emf” below into this manual:




**NOTE:** Even though the graph appears in your layout, this graphic is not automatically saved into the Map document. ArcMap only stores a reference to the graphic file on the hard drive, not the graphic itself. If you delete the *.emf file from the hard drive, then the graphic will be missing from your layout the next time you open your Map document. If you wish to save the actual graphic in the map document file itself, then right-click on the graphic, select 'Properties', select the 'Picture' tab, and check the box for 'Save Picture as Part of Document'. If you do this, then your Map document will increase in size by a few KB, and you can delete the *.emf file from the hard drive.

MINIMIZING THE DIALOG: If the Bottleneck Results dialog takes up too much screen space for you to see your map properly, you can temporarily shrink it by clicking the “Minimize” button. To reset it to full size, simply click the “Maximize” button.

TECHNICAL DETAILS: For those interested in the methods used by this function, the basic algorithm works as follows:

1) *Step 1: General Error-Checking:* Just makes sure that corridor and habitat block polygons are valid polygons, and that the corridor actually connects them. This step also confirms that the two habitat blocks are not already connected (or are possibly referring to the same polygon), in which case no corridor would be needed.

2) *Prepare the Corridor and Habitat Block Polygons:* This includes extracting only the outermost ring of the habitat block polygons so that any internal holes are ignored. The tool only intends to connect the outermost edges of the habitat block polygons and therefore internal holes are irrelevant to the analysis. This step also involves clipping the habitat polygons to the general extent of the corridor polygon and checking to see if any sub-polygons of possibly multi-part habitat polygons can be excluded from the analysis. All polygons are set to the projection of the corridor polygon.

3) *Generate a Raster Analysis Environment:* This function depends on least-cost-path analysis and therefore uses Spatial Analyst processes. The function generates a raster analysis environment based on the extent of the corridor polygon +10% on all sides. The cell size is calculated as the longer of the height vs. width of the analysis extent, divided by 1000.

4) *Generate a Distance from Edge Grid:* The “Distance from Edge” grid reflects the **internal** Euclidian distances from the edge of the corridor polygon. All regions outside the corridor polygon have a “Distance from Edge” value of 0.

5) *Identify Central Cells of Corridor:* This is done by treating the “Distance from Edge” grid as a pseudo-elevation dataset, where the highest “elevation” values naturally occur in the center of the polygon (i.e. with the highest “distance from edge” values). We then

perform a streamflow accumulation analysis on the "elevation" dataset and identify all those grid cells with zero accumulated streamflow. These represent the pseudo-ridgelines, or central cells, in the "Distance from Edge" grid.

6) *Generate Cost Grid through Corridor:* The cost grid has relatively low costs within the central cells, and extremely high costs elsewhere within the corridor. Areas outside the corridor are completely restricted from the analysis.

7) *Generate Cost Distance and Direction Grids:* This is done twice, using each of the two habitat blocks as an origin source.

8) *Generate a Set of Potential Centerline Routes:* Typically a large number of potential centerline routes will be generated. A least-cost-path polyline is generated at every point where one of the habitat polygon boundaries intersects a central cell (from step 5 above). There can be many such cells, especially if the corridor is multi-stranded or has holes. If a habitat polygon does not intersect any centerline cells (a rare but theoretically possible case), then a least-cost-path polyline is generated for all cells along the intersection of the habitat boundary line and the corridor polygon.

9) *Calculate Statistics on All Competing Routes:* For each of the routes generated in step 8 above, we identify:

   a. The narrowest point encountered along the route (measured at cell-sized [see step 3] intervals along the route using the "Distance from Edge" grid [see step 4]).

   b. The total accumulated cost of traveling the route (calculated at the endpoint of the route, using the "Cost Distance" grid generated in step 7 above).

   c. The total length of the route.

*10)* *Choose Best Route:* This is an iterative process:

   d. First the route(s) with the widest narrow point is selected. Only the routes that go through the widest parts of the corridor will be considered. If multiple routes have the same widest narrow point, then:

   e. From this subset, select the route(s) with the lowest accumulated travel cost. If there are still multiple routes, then:

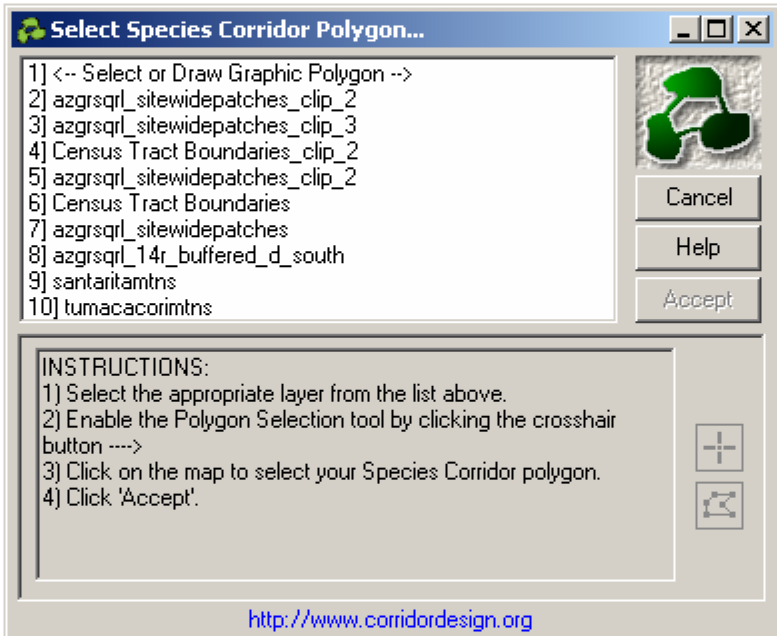
   f. From this new subset, select the shortest routes. If there are still multiple routes, then:

   g. At this point they are probably multiple versions of the same route, which might happen if the same route was generated going to and from each habitat block. In this case there is no real difference among the remaining routes, so simply take the first in the list.

*11)* *Complete the Analysis:* The corridor width values (calculated in step 9.a.) of the final selected route are then sent to the Bottleneck Results dialog, which then generates all statistics and graphs.

## Selecting or Drawing Polygons:

Four functions allow the user to do something based on a selected polygon graphic or polygon feature, and therefore all three tools needed a way to select or draw that polygon. The Patch Analysis, Bottleneck Analysis, Cross-Tabulation Table and Clip tools all provide access to the following dialog:

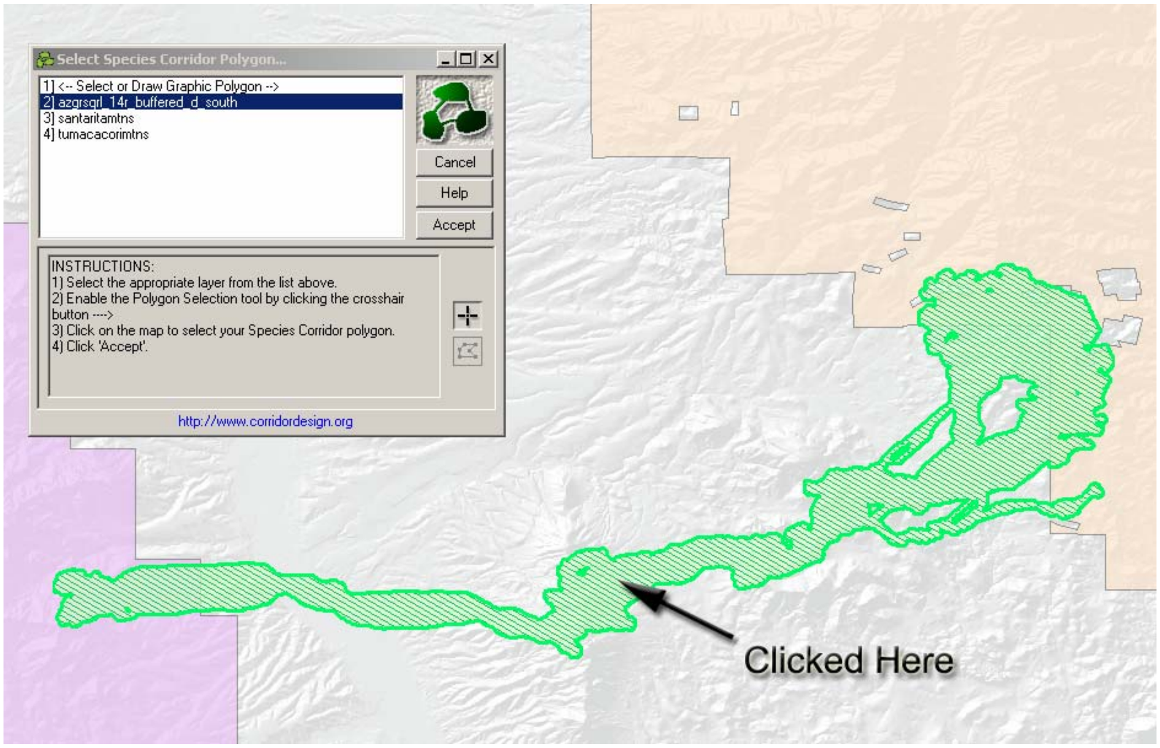


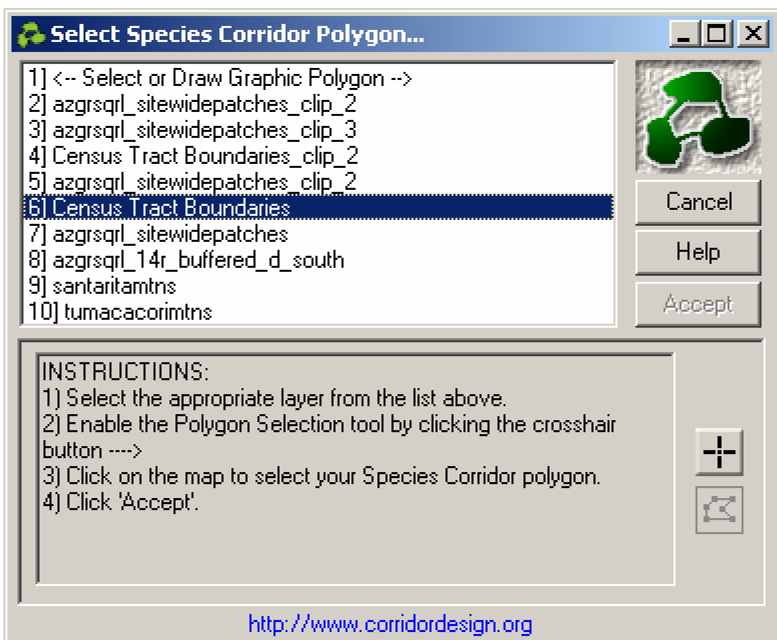

**NOTE:** The title of this dialog will change depending on whether the user is searching for a corridor polygon or a wildland block.

This dialog allows you to:

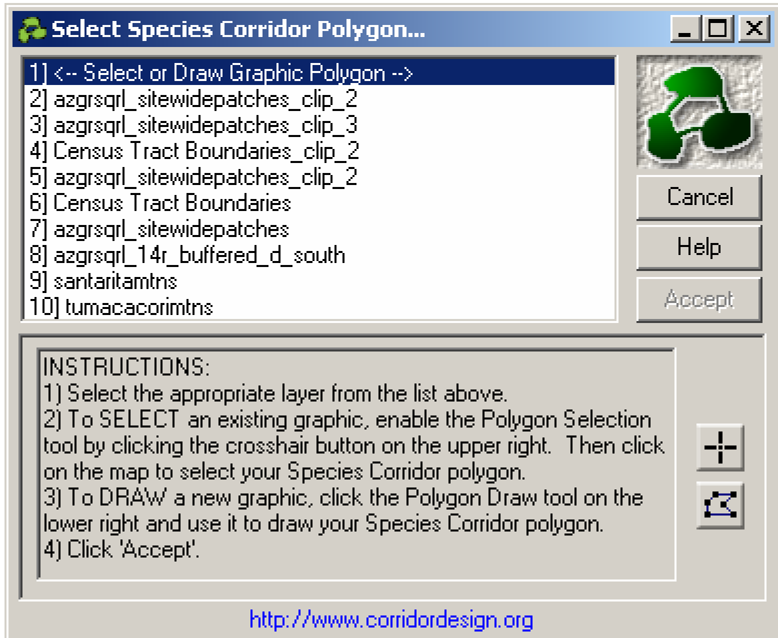
1. Select a single polygon from a polygon feature layer, or
2. Select a single graphic polygon, or
3. Manually draw a graphic polygon on the screen.

If you select a polygon theme from the list at the top of the dialog, then the “Select Polygon” button  will become enabled and the corresponding tool will become enabled on the Corridor Designer toolbar. Click this button and then select a polygon from the theme. After you click on a polygon, it will turn a green color with a crosshatch fill:



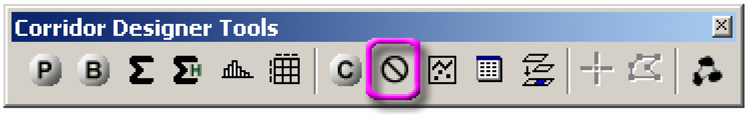




You may also select or draw graphic polygons, rather than selecting polygons from a polygon layer. If you select the first item in the list, "Draw or select graphic polygon", then both the "Select Polygon"  and "Draw Polygon"  buttons will become enabled. Use the appropriate button to either select or draw a graphic polygon. Note that the instructions change if you select this option:

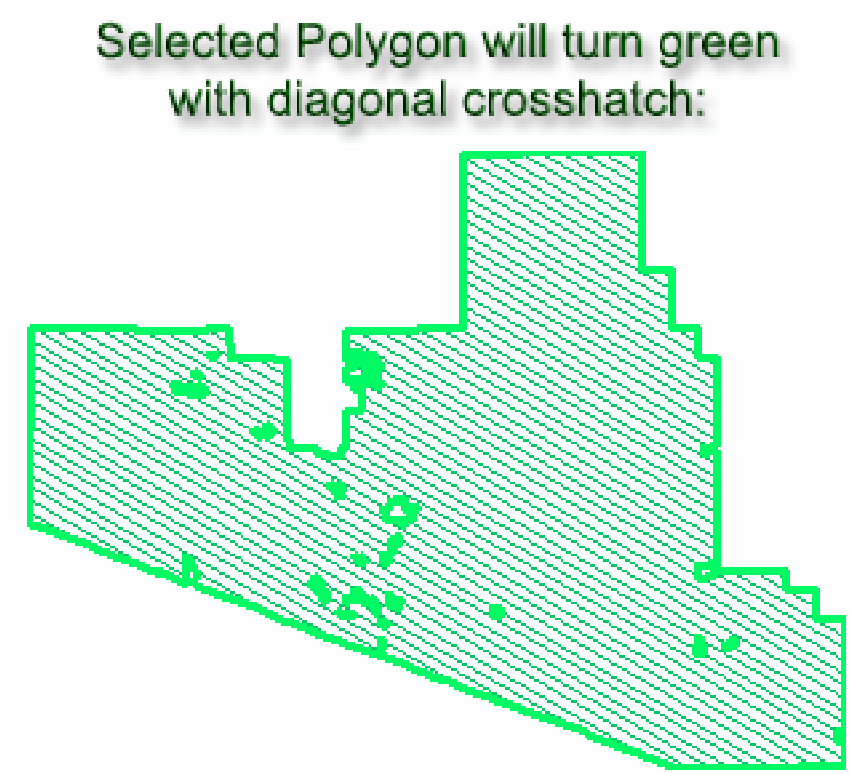



In all cases, selected polygons will be shaded green with a crosshatch pattern. If any of these graphics remain in your view after you no longer need them, you can quickly clear them out using the “Delete Corridor Designer Graphics” tool (p. 12). You may also convert any graphics to a shapefile using the “Create Shapefile” tool (p. 13).

## Delete Corridor Designer Graphics:




Several of the Corridor Designer Evaluation functions create graphics on the screen. For example, the Clip tool and the Polygon Selection tool both produce polygons with a particular fill pattern:




The bottleneck and patch distance tools will also produce distinctive graphics.

This button simply clears out any CorridorDesigner-produced graphics, leaving any other user-created graphics untouched.

## Create New Shapefile:

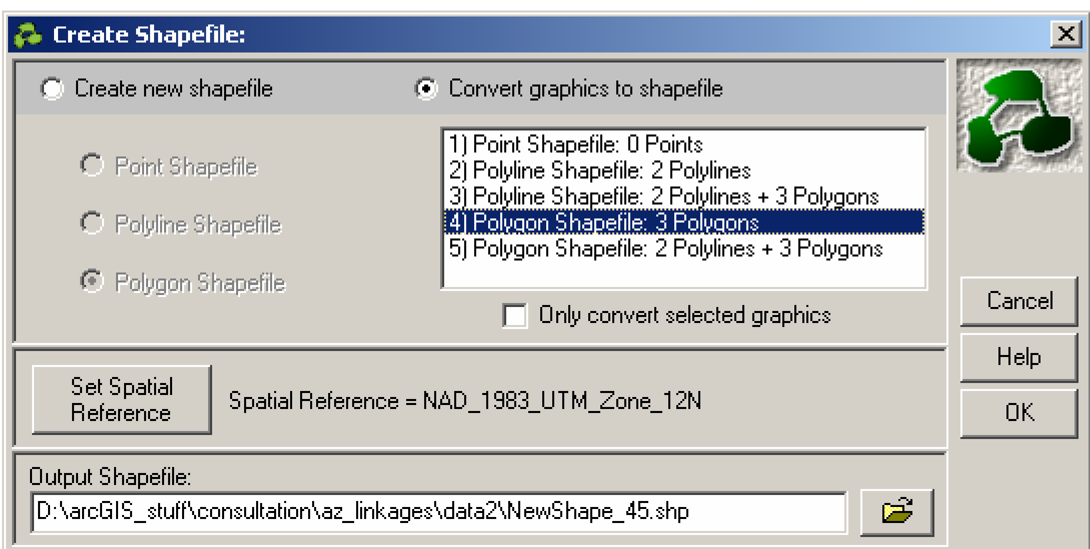

This function allows you to either create a new empty shapefile or convert graphic shapes to a shapefile. You may create either point, polyline or polygon shapefiles with this tool.

- Polygon shapefiles will include attribute fields for [Unique_ID] and [Area].
- Polyline shapefiles will include attribute fields for [Unique_ID] and [Length]
- Point shapefiles will include attribute fields for [Unique_ID], [X_Coord] and [Y_Coord].

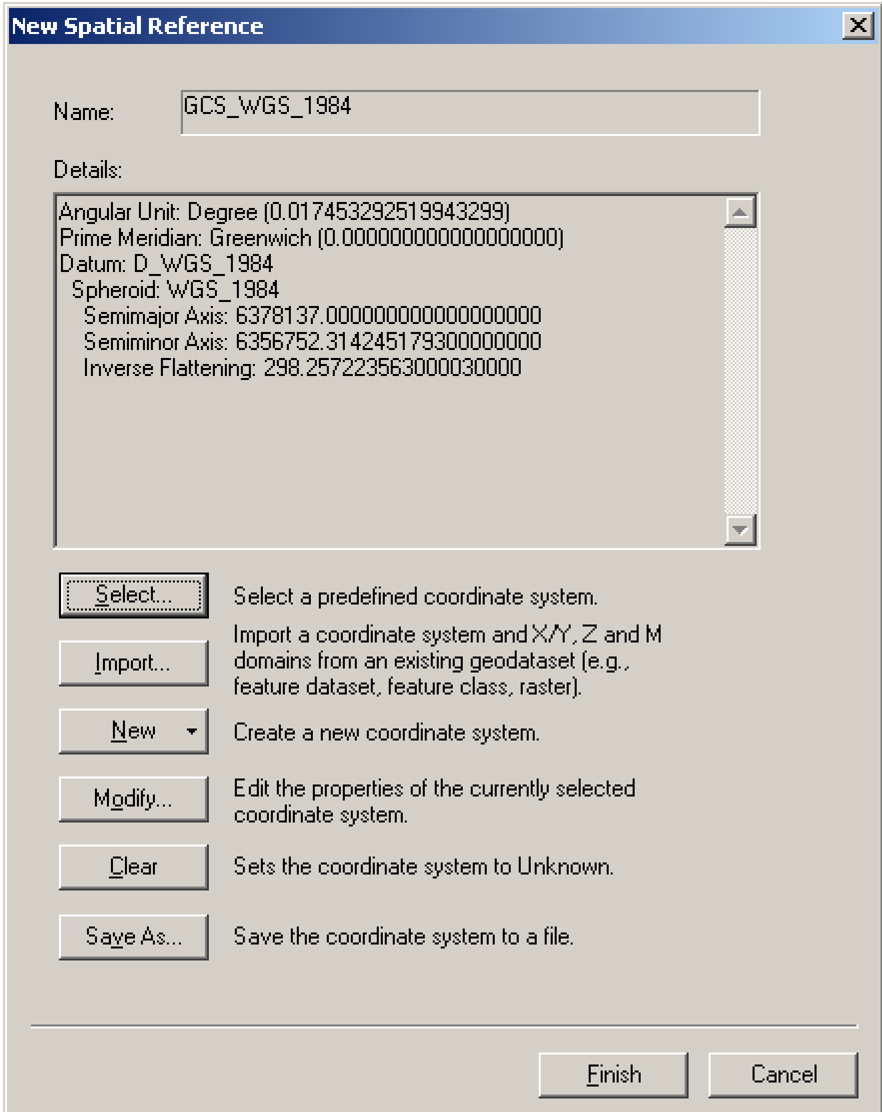
**NOTE:** If you are converting graphics to a shapefile, and if those graphics have names (right-click the graphic and check the properties to see if it has a name), then these names will also be added to the attribute table in a [Name] field.

This function also allows you to convert polyline graphics to polygons, or polygon graphics to polylines, if you wish. When opened, the tool will examine your map to see how many point, polyline or polygon graphics are available, and whether any of them are selected. The tool will show you how many of each type are available to convert. If you attempt to create a shapefile from existing graphics when there are no graphics to convert, you will be notified of this and asked if you would like to try a different shape type.

**NOTE:** Certain linear or areal graphic shapes are not technically polylines or polygons. Polygons that are defined by a circle or elliptic arc are not really "polygons" in the sense that they are not composed of a series of straight-line segments. This is also true for linear features that are constructed of Bezier curves. It is not possible to add true curves such as circles, ellipses or Bezier curves to a polyline or polygon shapefile, so this function will convert these shapes to standard polygons or polylines before adding them to the shapefile. It does this by generating 200 evenly-spaced points along the length or perimeter of the curve, and connecting these points with straight segments. Therefore, if the original graphic feature is composed of true curves, then the actual shape in the shapefile will be slightly different than the original feature.




You must set a spatial reference for the new shapefile. If your map has a spatial reference set, then the map spatial reference will be the default value. You may easily change the spatial reference by clicking the “Set Spatial Reference” button and identifying the spatial reference you want:




**NOTE:** This function adds the new shapefile to map, but does not delete existing graphics so you may not see the new shapefile when the shapes lie behind the graphics.