This exercise models a mapping workflow used by GIS public safety professionals and uses a simplified dataset for the City of Kent, Washington, and the adjoining Fire District 37.

Priming the Pump

Preparing data for concentration modeling with ArcGIS Network Analyst 9.2

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A Standard of Response Coverage, or SOC, includes careful measurement and modeling of two emergency service concepts—distribution and concentration. Distribution in this context refers to the amount of time required for initial service providers to arrive on scene and render aid.

"Development of a Standard of Response Coverage has been invaluable in helping us to define and evaluate our level of service. This tool is enabling us to demonstrate clearly to the community what they can expect as well as raising awareness within the department."

—Lynn Heesen, Battalion Chief Kent Fire Department

Distribution

Distribution analysis includes mapping the location of resources to assure an all-risk initial intervention can be effected within the specific time frame defined by the community and its emergency service provider. Typically, an emergency service provider is responsible for a delineated geographic area subdivided into contiguous subareas that are defined by time and/or distance response parameters. Distribution analyses account for total time required to receive and process a request for emergency assistance, activate service, and travel to the location. Although distribution times vary by community, most range between five and seven minutes.

Concentration

"Concentration is the spacing of multiple resources arranged close enough together so that an initial effective response force can be assembled on scene within adopted public policy time frames. An initial effective response force is that which will most likely stop the escalation of the emergency for that risk type."

—Commission on Fire Accreditation International (CFAI)

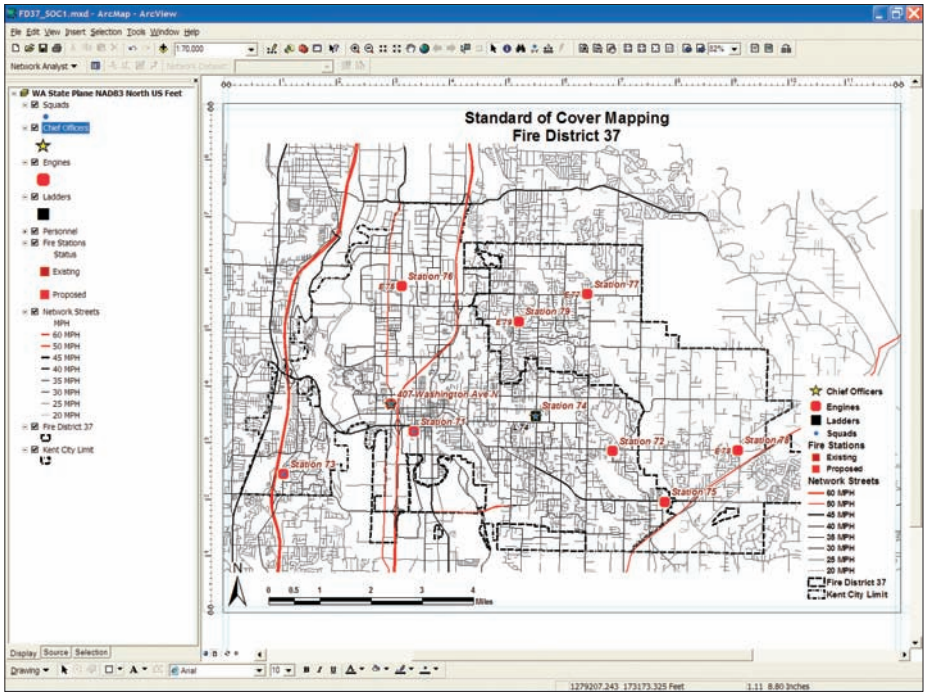
What you will need

- ArcGIS Desktop 9.2 (ArcInfo, ArcEditor, or ArcView)
- ArcGIS Network Analyst 9.2 extension
- Sample dataset from *ArcUser Online* (www.esri.com/arcuser)
- A zipping utility such as WinZip

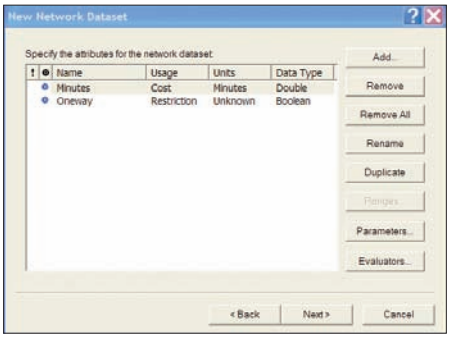
Target Audience

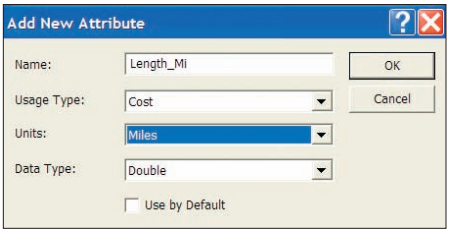
This article assumes the reader is familiar with the ArcGIS Desktop applications, ArcCatalog and ArcMap, and understands how to create a network dataset using ArcGIS Network Analyst 9.2 extension and/or has worked the tutorial "Got It Covered—Modeling Standard of Cover with ArcGIS Network Analyst" in the October–December 2006 issue of *ArcUser* magazine. This article showed readers how ArcGIS Network Analyst 9.2 can be used to create and map 4- and 8-minute travel area polygons for fire stations in the City of Kent, Washington, and the adjoining Fire District (FD) 37. It introduced a service area mapping workflow commonly used in public safety to map distribution and is available, along with the sample dataset, from the *ArcUser Online* Web site at www.esri.com/news/arcuser/1006/fall2006.html.

The exercise described in this article enhances the data for an 8-minute travel network to allow for a concentration assessment. The next step will be to model concentration and map the availability of emergency apparatus and personnel.



The map document included with the sample dataset for this exercise





In ArcCatalog, create a new network dataset. Manually add the Length_Mi field to hold distance values.

Concentration measures can be a percentage of total coverage area, percentage of equally sized analysis areas, or percentage of total road miles within the jurisdiction. The total time to achieve concentration includes modeling all the above distribution parameters as well as time for activation and deployment of additional services. As with distribution times, overall concentration goals are also established by the community and its service providers. Concentration, including call processing, activation, and travel times, typically ranges between 10 and 12 minutes.

This exercise models concentration using 8-minute travel from seven existing fire stations and three proposed fire stations. The existing stations are staffed by Fire District (FD) 37 personnel. The proposed stations are alternate and proposed sites defined by resource reallocation studies. Existing stations are numbered 71 through 77. Proposed stations 78 and 79 may be built on recently acquired parcels east of the city. The Washington station, with a full firefighting force including an engine, a ladder, and a chief, protects the downtown area, west of a major transportation corridor. Station attributes list anticipated apparatus and personnel at the proposed sites. To accommodate growth in the southeast and the west, District 37 plans to build and staff several new stations east of the city limits and one new station in the western portion of the core community.

Getting Started

This exercise repeats some of the modeling used in the previous tutorial using an advanced technique. Some updated local information and framework data will be included. Consequently, to properly perform this exercise, do not reuse data from the previous exercise. Instead, go to the *ArcUser Online* Web site (www.esri.com/arcuser) and download the new training data. This data will be used in upcoming national training sponsored by ESRI and the National Alliance for Public Safety GIS.

1. After downloading the sample dataset for this tutorial, unzip it at or near the root directory of a local drive. It creates a folder called FD37_2.

2. Open ArcCatalog and explore the files. This folder contains three subfolders named GRDFiles, Models, and SHPFiles. GRDFiles and SHPFiles folders both contain folders named WASP83NF. The shapefile WASP83NF subfolder contains several shapefiles and layer files; GRDFiles\WASP83NF is empty. The Models folder contains several scripted models that will be used to prepare, calculate, and map distribution. Closely inspect the Network Streets layer file; this is the street set that will support our transportation network. Close ArcCatalog.

3. Start ArcMap and load the FD37_SOC1 map document from \FD37_2. Switch to Layout View and inspect the document. Next to each fire station symbol is a label that lists the availability of apparatus and personnel.

4. Turn off the symbology for the four types of apparatus and study the underlying status symbology. Stations 71 through 77 are existing stations. Stations 78, 79, and 407 Washington Ave N (Washington) are proposed stations.

5. Open and inspect the Fire Stations attribute table. After the fire stations were geocoded from street addresses, project coordinates were calculated. Each station record in the attribute table contains an Index value that ranges from

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1 to 10. The Label field can be used to identify each station on the map.

The Index and Label fields will become very important later when modeling the service area. Study the apparatus deployment information contained in fields E_01, E_02, L_01, BC01, and S_01. These fields indicate the apparatus available at each station. The STAFF_T field counts each station's available response personnel. These numbers will be used to calculate the Effective Response Force (ERF). Look at the symbology and label properties for the individual apparatus and personnel layers to see how the labels are symbolized.

Creating a Street Network Dataset

ArcCatalog will be used to build the network dataset using a simplified version of the actual street network for the City of Kent that has been tuned to run quickly and consistently for this project.

1. Close ArcMap and reopen ArcCatalog. Verify that the ArcGIS Network Analyst extension is activated. From the ArcCatalog menu, select Tools > Extensions and check the Network Analyst extension.

2. Go to the SHPFiles\WASP83NF folder and check the shapefile and layer files in ArcCatalog.

3. Open attribute table for streets_nw.shp and inspect the impedance fields, LENGTH_MI, and MINUTES. Distance and time values in these fields will be used to assign costs to all network segments. One-way travel on the freeways will be respected by the dataset. (Learn how to calculate the time and distance values in the previous exercise.) For answers to questions about creating a network dataset, refer to "Got It Covered" in the October–December 2006 issue of *ArcUser* magazine.

4. Navigate to the streets_nw shapefile and right-click on its name. Select New Network Dataset to begin building the dataset, accept the default name streets_nw_ND, and click Next to continue.

a) Click on the Connectivity button and note that End Point is checked. Click OK and Next. Don't apply an elevation connectivity field because the streets include freeway overcrossings. Click Next again.

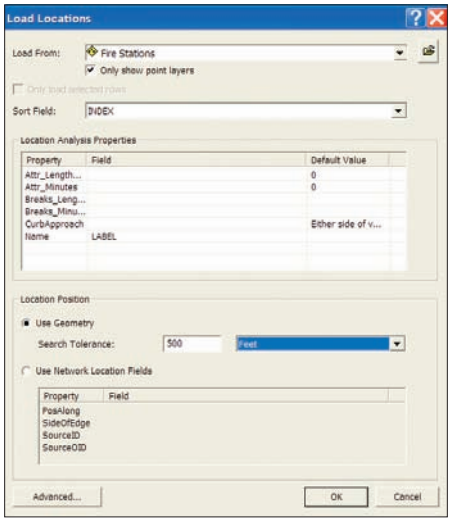
b) Accept Global Turn rules. Click Next. Notice that Minutes and Oneway are both reserved Network Analyst field names. Because these field names match the appropriate fields in the network dataset, Network Analyst identifies these fields and sets them up for the network.

c) Manually add Length_Mi, the distance field. Click Add and type Length_Mi in the Name box. Leave Usage Type as Cost, change Units to Miles, and leave Data Type as Double. Click Next again.

d) Click No to driving directions. Click Next.

e) Study the Network build parameters carefully and verify that all necessary parameters are set. Select and copy the contents of the summary window and paste it into a WordPad document. Save this file for future reference.

f) Click finish to create the new network dataset and Yes to build it. When finished, inspect the network dataset in ArcCatalog. Close ArcCatalog.



Load the fire stations into the new service area.

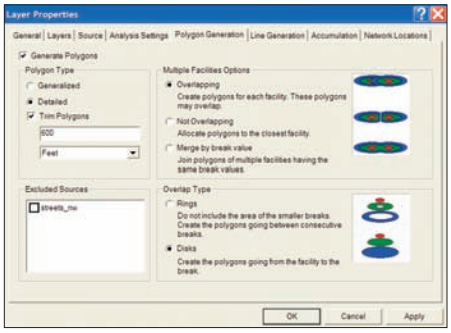
Building 8-Minute Travel Area

This exercise will model a Service Area by mapping 8-minute travel from all stations. Fire District 37 now staffs seven fire stations that are located in or near the city of Kent, Washington. After using Network Analyst to create 8-minute travel footprints for existing and proposed stations, the next step will be to model the best alternatives for deploying equipment and personnel.

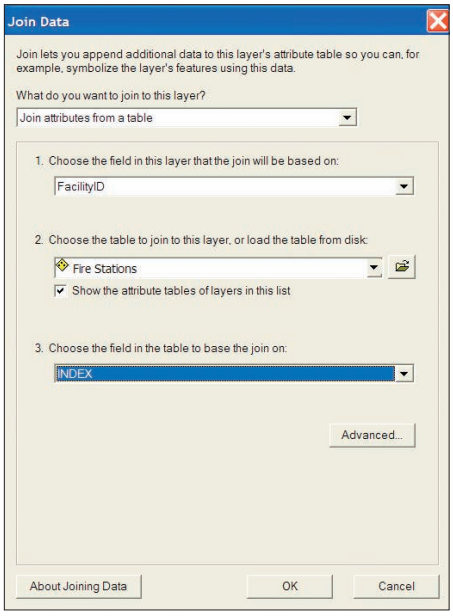
1. Return to ArcMap and reopen FD37_SOC.mxd. Check that an ArcGIS Network Analyst 9.2 extension license is available to ArcMap by choosing Tools > Extensions from the menu. Load the Network Analyst toolbar and explore the drop-down menu. Float the mouse cursor over the tool buttons to view the name of each tool.

2. Click the Add Data button and navigate to \SHPFiles\WASP83NF. Add Streets_nw_ND to the map. In the next dialog box, click No to avoid adding all other participating feature classes. In the table of contents (TOC), place the network dataset immediately below Network Streets.

3. Click the Show/Hide Network Analyst button to open this window. It will be empty.



Set the properties for the service area.



Use a join to add more information about the fire stations in the service area.

Click the Network Analyst drop-down menu and select New Service Area. The Network Analyst Window sees the new Service Area and lists four possible network data types: Facilities, Barriers, Polygons, and Lines.

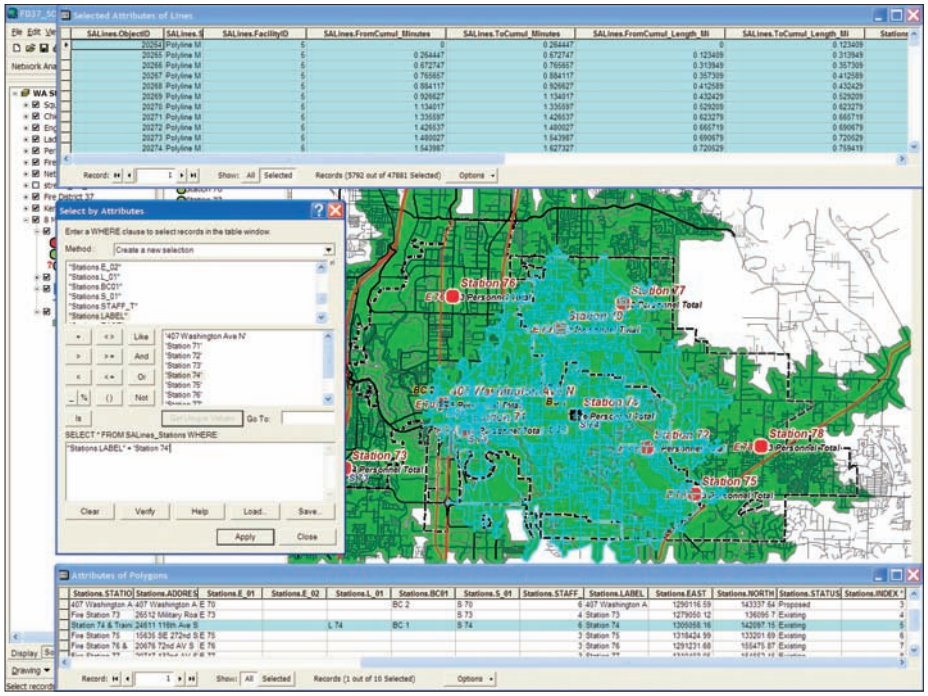
4. Load the fire stations. Right-click on Facilities and select Load Locations. In the Load Locations dialog box, select Fire Stations as the Facilities layer, specify INDEX as the Sort by parameter, and change the Name property from the Address field to the LABEL field. Change the Search Tolerance to 500 feet. This will limit the search for station locations to within one block of existing streets. This should be sufficient for locating new and current stations.

5. Click OK to accept these parameters and load the fire stations. Expand the Facilities layer in the Network Analyst window to verify that 10 stations have been added.

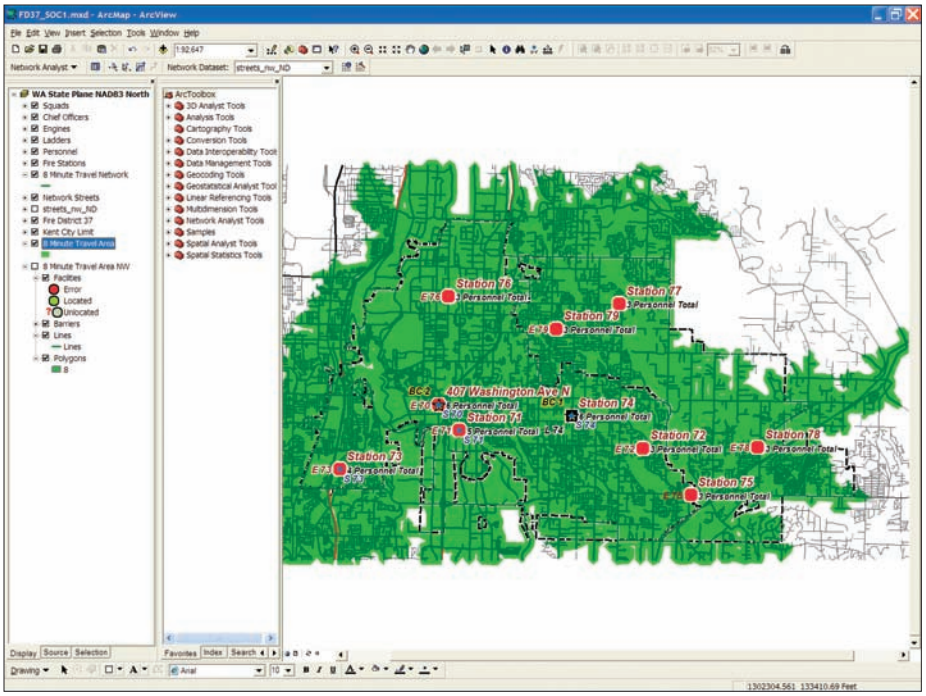
6. Right-click the Service Area (SA) name in the TOC and open Properties. A Layer Properties dialog box opens, displaying eight tabbed

options. Click on each tab and fill in the values specified in the table in Figure 1. Where values are not specified on a tab, accept the default values. Accept all default values for the Network Locations tab.

7. Now, let's calculate the 8-minute travel areas. In the TOC, reposition 8 Minute Travel Area NW at the bottom of the data stack, right-click on its name, and select Solve. This solution will take some time because it requires trimming polygons, and traveling farther from stations, which creates significant but desired overlap. When the solver finishes, modify the line thickness and color to show a dark green line that is 2 points in width. Change the transparency display for the polygon to 0 percent and apply a medium green color. Save the project.



Use Select by Attributes to highlight the travel network and area for Station 74.



Export the Lines and Polygon layers in the service area as shapefiles to preserve the table joins.

Joining Station Parameters with Travel Networks and Areas

After adding fire station data to the travel networks using a join, these layers will be exported so they will be independent of the service area and can be used for other map documents.

1. In the 8-Minute Travel group, locate Polygons and open its attribute table. Notice that the Name field contains a reference to each station and lists the time interval applied in the solver.

2. Open the attribute table for Lines. It does not contain a station name reference, but it does contain a FacilityID that corresponds to the INDEX field that was assigned in the network properties. Fire Stations data will be joined to these tables using the station's Index field and the travel data's FacilityID.

3. Close or minimize any open attribute tables and right-click on Polygons in the 8-Minute Travel group and choose Joins and Relates > Joins from the context menu. In the Join dialog box, select Joins from a Table and fill in the three fields in the dialog box as follows:

- FacilityID
- Fire Stations
- INDEX

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Tab	Setting
General	
Name	8-Minute Travel Area NW
Analysis Settings	
Impendance	Minutes
Default Breaks	8
Polygon Generation	
Generate Polygons	Checked
Polygon Type	Detailed
Trim Polygons	600 Feet
Excluded Sources	None
Multiple Facility Options	Overlapping
Overlap Type	Disks
Line Generation	
Generate Lines	Checked
Accumulation	
Length_MI	Checked
Minutes	Checked

Figure 1: 8-Minute Travel Area wizard settings

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Click OK to create the join.

4. Create an identical Join for the 8-Minute Travel group Lines layer. Check that the tables have actually been joined by opening the attribute tables for Polygons and Lines and verifying that the data is properly joined.

5. In each attribute table, use Select By Attributes to choose one station to highlight its travel network and travel area. Notice how it overlaps with the travel area and network footprints of other stations.

6. Export the joined data into two new shapefiles to preserve the joins and travel areas so they can be used with other map documents. In ArcMap's menu, choose Selection > Clear Selected Features.

7. In the TOC, right-click on Polygons and select Data, then Export Data. Export all features, use the data frame's coordinate system, and place the new shapefile in \SHPFiles\WASP83NF\; name it Sarea08.shp. Add the new shapefile and place it immediately above the 8 Minute Travel group. Double-click on Sarea08 and use the Layer Properties dialog box to change the name to 8 Minute Travel Area. Fill it with a medium green color.

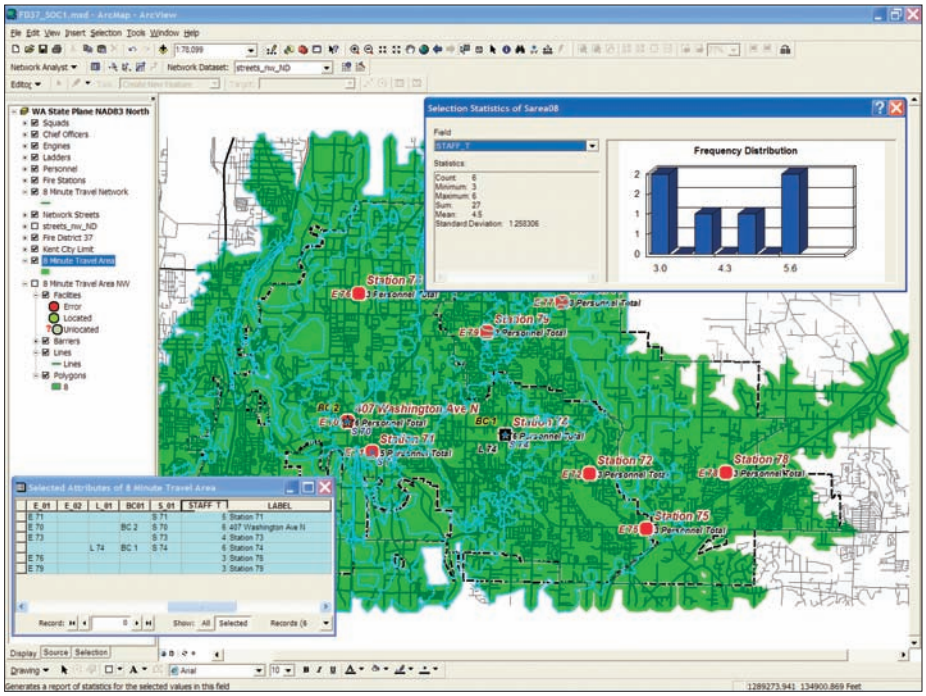
8. Repeat the export process for Lines, saving this layer as \SHPFiles\WASP83NF\Snet08.shp. Use the same process to rename Snet08 to 8-Minute Travel Network and change its symbology to a 2 point dark green line type. Save the map.

Development of a Standard of Response Coverage, or SOC, includes careful measurement and modeling distribution and concentration.

Exploring and Analyzing Data

Close the Network Analyst Window to increase the data frame area, inspect the data, and answer some questions. In the TOC, click the Selection tab and check only the box next to the 8-Minute Travel Area to make it selectable. Click on the Display tab in the TOC. Pick the Identify tool, and set Identify From to <Selectable Layers>. Move the Identify window to the lower left portion of the screen.

1. Click the Identify tool in an area between the Washington Station and Station 71. This should return a list of six stations. Click on each station record in the Identify dialog box and flash its 8-minute travel footprint. Notice the considerable coverage overlap in the downtown area. How many firefighters are available in our identified area?



Use Statistics to learn more about the available fire personnel.

2. Close the Identify window, switch to the Select Features tool, and click in the same area. Open the 8-Minute Travel Area attribute table and click the button on the table frame to show only the selected records.

3. Scroll right across the table and locate the STAFF_T field. Right-click on this field and request Statistics. The Sum line shows that 27 firefighters are available. Two battalion chiefs, five engines, one ladder, and four squads are all available within an 8-minute drive.

4. Since concentration requires only one battalion chief, three engines, and one ladder, there are apparatus to spare. If Station 74 was fully deployed on another call, would the service area still have full concentration? Yes, because the effective fighting force still has 19 firefighters.

Select other areas and test concentration. Switch the selectable set to 8-Minute Travel Network and study the travel network. Save the project.

Future Activities

With time- and distance-based data created. additional analyses could be performed such as calculating an effective response force, experimenting with concentration variables (including repositioned apparatus and personnel), and comparing historic response times to modeled values.

Additional Resources

For more information on using the ArcGIS Network Analyst extension, see the free ESRI Virtual Campus training seminar, *Introduction to ArcGIS Network Analyst*, and the instructor-led ESRI course, *Working with ArcGIS Network Analyst*. Learn more about these offerings at www.esri.com/training. Several instructional podcasts on ArcGIS Network Analyst are also available from www.esri.com/podcasts at no charge. These podcasts include

- ArcGIS Network Analyst: Network Datasets
- ArcGIS Network Analyst: Networks and Network Models
- ArcGIS Network Analyst: Setting Network Dataset Connectivity, Part 1
- ArcGIS Network Analyst: Setting Network Dataset Connectivity, Part 2

Acknowledgments

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