



Preparing Street Data for Use with the Network Dataset

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An ESRI Technical Paper

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Preparing Street Data for Use with the Network Dataset

Introduction Street datasets for routing are very common. Many commercial data vendors sell these datasets with a rich set of routing attributes. Other datasets are constructed and maintained internally for the private use of an organization and have a targeted set of routing attributes. In order to perform analysis on the data using the ArcGIS® Network Analyst extension, a network dataset must be created on this data with the appropriate network connectivity settings and attributes defined.

This paper discusses the necessary data preprocessing to prepare routing attributes on a Streets feature class and a Turns feature class for use in a network dataset and also discusses what settings to use when creating the network dataset to reference these attributes. The paper concludes with verification routines to perform to ensure that the network is created correctly. It assumes that the reader is familiar with using ArcGIS and has a basic understanding of the network dataset, the turn feature class, and ArcGIS Network Analyst. For more information on these concepts, see the Network Analyst section of the ArcGIS Desktop Help.

The Streets Feature Class The Streets feature class is a line feature class that contains the geometry and routing attributes for the streets. This feature class will be used as an edge feature source in the network dataset. In the sections that follow, we will walk through the steps for creating the Streets feature class with examples of common and necessary fields so it may be used in a network dataset.

Create the Streets Feature Class A routing dataset typically contains one feature class that contains the geometry for all the streets. This feature class will be used as the Streets feature class in the network dataset. Since the Streets feature class will be used as an edge feature source in a network dataset, the feature class must be either a shapefile or a geodatabase feature class inside a feature dataset. If your street data is not in one of these formats, you will need to convert this feature class using the Feature Class To Feature Class geoprocessing tool in ArcToolbox™. This will create the Streets feature class that will be used in the network dataset.

Because edge feature sources in the network dataset rely on geometric coincidence to determine connectivity, the Streets feature class must also have polyline geometry in which the line features connect to other line features either at coincident endpoints (End Point connectivity), or at all coincident vertices (Any Vertex connectivity). Most routing datasets have the street data represented by polyline features where coincident endpoints indicate that the corresponding streets connect to each other. See the documentation for your routing dataset for more details.

If the polyline features in your dataset are not coincident, you must edit these features such that lines that connect to each other have coincident vertices. Otherwise, the network dataset that is built from these noncoincident features could yield undesired routing results. You can use the Integrate tool in ArcToolbox to clean your data to make nearby vertices coincident with each other. See the ArcGIS Desktop Help for information on how to use the Integrate tool. If you have an ArcEditor™ license, you can set up a geodatabase topology to not only help you determine where polyline vertices are currently not coincident but also to enforce topology rules to ensure that future edits to your data have the proper geometric coincidence. See the Topology topics in the ArcGIS Desktop Help for more information.

Remove Duplicate Street Features

A street can sometimes have more than one name. This typically occurs when there is a local name, a highway number, and a highway name assigned to that street. For example, a street may be known as Main Street, State Highway 99, County Road G4, and Transcontinental Highway.

In some datasets, when a street has more than one name, it is represented as multiple coincident features, where each feature contains one of the names. This is typically done so that points can be geocoded on any of the street names. In most routing datasets, the same unique identifier is assigned to each of these features. See the documentation for your routing dataset for more details. Unfortunately, having multiple features to represent the same street causes a network to act as if there are multiple streets at that location. If your data has multiple features representing a single street, then you will need to create additional text fields on the Streets feature class to hold the alternate street names. For each of the streets with multiple street names, it is recommended to do the following:

1. Identify which of the street features holds the primary street name. In most routing data, there is a field that indicates which name is primary. See the documentation for your routing dataset for more details.
2. Copy the name from each of the nonprimary features into the newly created alternate street name fields on the primary street feature.
3. Delete the nonprimary street features.

The following example shows a Streets feature class containing four records with four street names representing one street.

OID	STREET ID	PREFIX	NAME	TYPE	SUFFIX
11	1001	W	Main	Street	
12	1001		State Highway 99		
13	1001		County Road G4		
14	1001		Transcontinental	Highway	

You will need to edit the Streets feature class to contain only one feature to represent that street with the following field values:

Field	Value
OID	11
STREET_ID	1001
PREFIX	W
NAME	Main
TYPE	Street
SUFFIX	
PREFIX1	
NAME1	State Highway 99
TYPE1	
SUFFIX1	
PREFIX2	
NAME2	County Road G4
TYPE2	
SUFFIX2	
PREFIX3	
NAME3	Transcontinental
TYPE3	Highway
SUFFIX3	

The additional name fields on the feature class can be used when giving driving directions on a street that has multiple names. These name fields can also be used for geocoding through a composite address locator. For more information on setting up and using a composite address locator, see the Geocoding topics in the ArcGIS Desktop Help.

Add Fields to the Streets Feature Class

Most of the connectivity and attribute settings of the network dataset are derived from the field values of the source feature classes. Below is a list of the fields that can be used by the network dataset.

- Endpoint elevation values for overpass/underpass connectivity
- Impedance (cost) attribute values
- Restriction attribute values
- Hierarchy attribute values
- Street names for driving directions
- Highway shields for driving directions
- Boundary field for driving directions

For more information on how these fields are used by the network dataset, see the Network Dataset Concepts topics in the ArcGIS Desktop Help. In the appendix of this paper, there is a sample list of fields that can be used in a network dataset for several commercial street datasets.

Most of these fields are typically already on the Streets feature class. However, in some street datasets, this information is stored in a field on a separate table with a reference to the street by its unique ID. If this is the case, you need to do the following to copy the field to the Streets feature class:

1. Create a new empty field on the Streets feature class that is the same data type as the remote field to be copied.

2. Join the remote table to the Streets feature class by the unique ID.
3. Use the Calculate command to copy the field values from the remote field to the newly created field on the Streets feature class.
 - a. Right-click the feature layer and click Open Attribute Table.
 - b. Right-click the field created in step 1 above and click Calculate Values.
 - c. In the Fields list in the upper left-hand corner of the Field Calculator, select the name of the joined field to copy. When you click, the field name will be added to the expression surrounded by brackets (e.g., [myRemoteTable.myField]).
 - d. Click OK to perform the calculation.
4. Remove the Join.

For example, suppose that the one-way street information is not stored on the Streets feature class but, instead, is stored on a separate table as shown below.

Streets Feature Class

OID	SHAPE	STREET_ID	PREFIX	NAME	TYPE	SUFFIX
1	<i>Polyline</i>	101		First	Street	SW
3	<i>Polyline</i>	102		Second	Street	SW
5	<i>Polyline</i>	103		Third	Street	SW
7	<i>Polyline</i>	104		Fourth	Street	SW
9	<i>Polyline</i>	105		Fifth	Street	SW

Remote Table Containing the One-Way Street Information

OID	STREET_ID	ONE_WAY
42	101	FT
43	103	TF
44	105	FT

Performing the above steps results in the contents of the ONE_WAY field being added to the Streets feature class, as follows:

OID	SHAPE	STREET_ID	PREFIX	NAME	TYPE	SUFFIX	ONE_WAY
1	<i>Polyline</i>	101		First	Street	SW	FT
3	<i>Polyline</i>	102		Second	Street	SW	
5	<i>Polyline</i>	103		Third	Street	SW	TF
7	<i>Polyline</i>	104		Fourth	Street	SW	
9	<i>Polyline</i>	105		Fifth	Street	SW	FT

You may also want to copy fields that are not network attributes in themselves but can be used in defining a network attribute. For example, a Speed Limit field can be used in conjunction with a distance attribute to create a travel time cost attribute. Other examples are fields that indicate whether a road is paved or if it is a toll road. These fields can be used in a network field expression evaluator to create restriction attributes that avoid unpaved roads and toll roads.

Create the Network Dataset

The Streets feature class is now ready to be used as an edge feature source in the network dataset. For most of the parameters for the network dataset, simply specify in the New Network Dataset wizard the appropriate field to use for that setting. If the fields have names that are recognized by the wizard, those fields will automatically be mapped to the appropriate settings. The field names that the wizard automatically recognizes are controlled by the NetworkDatasetConfiguration.xml configuration file located at <ArcGIS Install Directory>\NetworkAnalyst\NetworkConfiguration\. This file can be modified such that the wizard will automatically recognize other field names.

Although most parameters are a simple specification of a field, there are a few settings that are not as simple.

- When specifying a restriction attribute, you must enter an expression that evaluates to a Boolean value. If the value equates to True, then the street is restricted; otherwise, it is traversable. For example, suppose you have a field, `IsPaved`, that contains "Y" if the road is paved and "N" if the road is unpaved, and you want to create a restriction attribute that avoids unpaved roads. You would enter the following expression, with the return value being `res`.

```
If [IsPaved] = "Y" Then
    res = False
Else
    res = True
End If
```

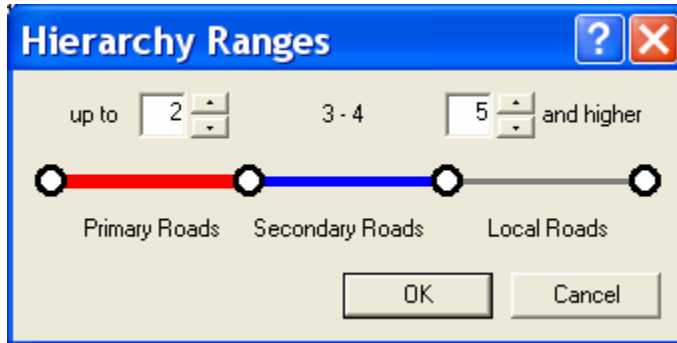
On the other hand, suppose you have a field, `IsToll`, that contains "Y" if the road is a toll road and "N" if the road is not a toll road, and you want to create a restriction attribute that avoids all toll roads. This time, the expression is reversed.

```
If [IsToll] = "Y" Then
    res = True
Else
    res = False
End If
```

The above expressions can be further simplified such that the return value is a single conditional statement of when the expression is true. In the examples above, the first expression can be simplified to `[IsPaved] = "N"` while the second expression can be simplified to `[IsToll] = "Y"`.

Simplifying the expressions improves the network dataset build speed, since the field evaluator would not need to interpret an `IF` statement.

- When specifying a hierarchy attribute, you must also specify which range of values correspond to each of the three levels of hierarchy that are used by the Network Analyst solvers.



See the white paper *Hierarchical Routes in ArcGIS Network Analyst* at <http://support.esri.com> for more information about choosing the appropriate hierarchy range values.

The Turns Feature Class

This section will discuss how to create the Turns feature class and add it to the network dataset you just created.

Many routing datasets contain information on specific turning movements that are either restricted or are known to take a lot of time to make. The way this information is formatted varies greatly from one dataset to another. Some datasets contain this turn information in an alternative ESRI format, such as ArcView® 3.x Network Analyst turn table format or ArcInfo® Workstation turn table format. The next two sections discuss how to create the Turns feature class. The first of the two sections discusses how to create the Turns feature class from an alternate ESRI format, while the second section discusses how to create the Turns feature class from a generic data format.

Create the Turns Feature Class from an Older ESRI Format

The Turns feature class can be created from an ArcView 3.x Network Analyst turn table or an ArcInfo Workstation turn table by using the Turn Table To Turn Feature Class geoprocessing tool. For the Reference Line Features parameter, be sure to use the Streets feature class that you are using in your network dataset. This tool will create the Turns feature class with the same additional fields that are on the turn table. You can add on other fields in the same way you did for the Streets feature class above.

Some datasets provide two-edge turns in an older ESRI format, while providing turns with more edges in a generic format. The next section provides the steps on how to convert these longer turns to a turn feature class. If your dataset does not have these longer turns, then you can skip the next section.

Create the Turns Feature Class from a Generic Format

Most turn datasets identify the turn by a sequence of unique street IDs, even though the actual table format of this information can vary widely from one dataset to another. The following steps will demonstrate how to convert these sequences of unique street IDs to a feature in the Turns feature class. You may want to write a script in ArcObjects™ that performs the data processing on the table format that is specific to your data. To get you started, a developer sample can be found in the ArcObjects Developer Help under Samples > NetworkAnalyst > Create Turn Feature Class From Multi-Edge Turn Table.

1. Create the new Turns feature class using the Create Turn Feature Class geoprocessing tool. Be sure that the Maximum Edges parameter is large enough to accommodate the longest turn in your data. Also, specify the Input Network Dataset parameter to be the network dataset you created earlier on the Streets feature class.
2. Add fields named AltID1, AltID2, AltID3, and so forth, to this turn feature class for each edge that the turn feature class supports. For example, if in the previous step, the Maximum Edges parameter was set to 7, then you would create the fields AltID1, AltID2, AltID3, AltID4, AltID5, AltID6, and AltID7. The format of these fields should be the same format as the unique ID field (e.g., STREET_ID) on the Streets feature class.
3. Add other fields to the Turns feature class for holding the restriction and cost attribute values.
4. For each turn feature, you will
 - a. Populate the AltID# fields with the unique street IDs of the turn. If the turn does not use all of the AltID# fields, leave the unused AltID fields with a value of zero. For example, if this turn consists of three edges, but the turn feature class can accommodate turns of up to seven edges, populate AltID1 with the unique street ID of the first edge in the turn, AltID2 with the unique street ID of the second edge in the turn, AltID3 with the unique street ID of the third edge in the turn, and AltID4 through AltID7 with zero.
 - b. Populate the Edge#FID fields for each edge in the turn with the feature ID or object ID of each street feature that participates in the turn. For the example of the three-edge turn mentioned earlier, Edge1FID, Edge2FID, and Edge3FID will be populated with the feature IDs of the first, second, and third street features in the turn respectively. Edge4FID through Edge7FID will be zero.
 - c. Populate the Shape field with a polyline geometry that coincides with the geometries of the underlying street features. Trim the geometry such that the start and end of the polyline are coincident with the middles of the first and last street features in the turn.
 - d. Populate the Edge#FCID fields for each edge in the turn with the feature class ID of the Streets feature class. The feature class ID can be obtained by calling the ArcObjects method, IFeatureClass::get_FeatureClassID(). For the example of the three-edge turn mentioned earlier, Edge1FCID, Edge2FCID, and

Edge3FCID will be populated with the feature class ID of the Streets feature class. Edge4FCID through Edge7FCID will be zero.

- e. Populate the Edge#Pos fields for each edge in the turn with the position of the edge along the feature. If all edges in the network dataset are formed from whole features (i.e., all edge connectivity policies are End Point and all the junction connectivity policies are Honor), then the Edge#Pos values can all be 0.5. For the example of the three-edge turn mentioned earlier, Edge1Pos, Edge2Pos, and Edge3Pos will be populated with 0.5. Edge4Pos through Edge7Pos will be zero.
- f. Populate the Edge1End field with "Y" if the turn travels along the digitized direction of the first edge in the turn, or "N" if the turn travels against the digitized direction of the first edge in the turn.
- g. Populate the attribute information on the Turns feature.

For example, suppose you had the following Streets feature class that used endpoint connectivity in the network dataset, and the following turn information tables:

Streets Feature Class (Feature Class ID = 78)

OID	SHAPE	STREET_ID	PREFIX	NAME	TYPE	SUFFIX
11	<i>Polyline</i>	101		Main	Place	
13	<i>Polyline</i>	102	W	Main	Street	
15	<i>Polyline</i>	103	N	First	Street	
17	<i>Polyline</i>	188	E	Main	Street	
19	<i>Polyline</i>	189	N	Tenth	Street	

Turn Attribute Table

OID	TURN ID	DIR FIRST EDGE	CAR RESTRICT	TRUCK RESTRICT
41	501	Against	Y	Y
42	502	Along	N	Y

Turn-Street Relationship Table

OID	TURN ID	SEQUENCE	STREET ID
61	501	1	101
62	501	2	102
63	501	3	103
64	502	1	188
65	502	2	189

Following the steps above, you would create the following two records in your Turns feature class:

Field	Value
EDGE1END	N
EDGE1FCID	78
EDGE1FID	11
EDGE1POS	0.5
EDGE2FCID	78
EDGE2FID	13
EDGE2POS	0.5
EDGE3FCID	78
EDGE3FID	15
EDGE3POS	0.5
EDGE4FCID	0
EDGE4FID	0
EDGE4POS	0
EDGE5FCID	0
EDGE5FID	0
EDGE5POS	0
ALTID1	101
ALTID2	102
ALTID3	103
ALTID4	0
ALTID5	0
TURN_ID	501
CAR_RESTRICT	Y
TRUCK_RESTRICT	Y

Field	Value
EDGE1END	Y
EDGE1FCID	78
EDGE1FID	17
EDGE1POS	0.5
EDGE2FCID	78
EDGE2FID	19
EDGE2POS	0.5
EDGE3FCID	0
EDGE3FID	0
EDGE3POS	0
EDGE4FCID	0
EDGE4FID	0
EDGE4POS	0
EDGE5FCID	0
EDGE5FID	0
EDGE5POS	0
ALTID1	188
ALTID2	189
ALTID3	0
ALTID4	0
ALTID5	0
TURN_ID	502
CAR_RESTRICT	N
TRUCK_RESTRICT	Y

Add the Turns Feature Class to the Network Dataset

Whether you created your Turns feature class from an older ESRI turn table format or manually populated the Turns feature class from the sequence of unique street IDs in the turn, the next step is to add this Turns feature class to the network dataset. After adding the feature class as a turn feature source, be sure to specify the evaluators for each network attribute in the network dataset. For example, there may be a travel time attribute in the network dataset in which travel times are already defined for the lengths of the streets. You can specify an evaluator on that attribute that specifies the travel times for the turns. When you perform a network analysis with this travel time attribute, it will account for both the time to travel along the streets as well as the time it takes to make the turns.

If necessary, create new attributes that are specific to the Turns feature class. For example, the turn features may specify which turns are restricted during the morning rush hour. In this case, you would create a new restriction attribute in the network dataset and specify the evaluator for the turn feature source to specify all the turns that are restricted during the morning rush hour.

Build and Verify the Network Dataset

The final step in creating the network dataset is to build the network dataset and verify that it was created correctly. Perform some network analyses, such as Routes and Service Areas, on the network dataset with varying combinations of impedance attribute, restrictions, and hierarchy, and compare the results to what you would expect. If the results are not correct, use the Network Identify tool to verify that the attribute values on each element are correct, as well as verify that the network element is connected to other

elements appropriately (see the ArcGIS Desktop Help for more information on how to use the Network Identify tool). Below are some common routing errors to check for in the network dataset.

- Connectivity of the roads forming an overpass/underpass
- Connectivity of ramps to the appropriate highway and/or street
- Connectivity of roads between hierarchy levels when performing analyses using hierarchy
- Restriction of one-way streets
- Restriction of turns
- Restrictions of streets and turns that are specific to a type of vehicle
- Travel time attribute values on both the streets and the turns

If the data is incorrect, edit the data to make the correction. If the attribute evaluators are incorrect, then correct the schema of the network dataset. After each correction, rebuild the network dataset, and rerun your verification routine again to make sure that the network dataset is now correct.

Summary

This paper began with a discussion on how to create a Streets feature class that included all of the fields necessary for use in the network dataset. It discussed how to eliminate duplicate records from the Streets feature class, as well as how to add fields from another table to the feature class. Once the Streets feature class was ready to be added to a network dataset, there were a few tips on how to create restriction and hierarchy network attributes.

Next, the paper discussed how to create a Turns feature class, from both an older ESRI turn table and from a generic sequence of street IDs, and how to add it to the network dataset and set up the network attributes specific to the turn feature source.

Finally, the paper concluded with a discussion on how to use the Network Analyst solvers and the Network Identify tool to verify that the network dataset was created correctly.

Appendix: Sample Fields to Use in the Network Dataset

Below are sample lists of fields to use when creating a network dataset from various commercial routing datasets. Each list indicates for each field the data layer in which it is found and how the field is used in the network dataset. The fields you actually use in your own network dataset may vary, depending on your modeling objectives.

All fields used by the network dataset must be copied to the Streets feature class or the Turns feature class. Note that not all remote tables have a one-to-one correspondence with the base Streets or Turns feature class. See the documentation provided by the data vendor for information on how these situations are to be interpreted.

NAVTEQ's NavStreets™ Premium Street Data 3.3.0—ArcView Format

Field	Data Layer	Usage in the Network Dataset
St Nm Pref	Streets	Directions street name field—Prefix
St Typ Bef	Streets	Directions street name field—Prefix Type
St Nm Base	Streets	Directions street name field—Name
St Nm Suff	Streets	Directions street name field—Suffix
St Typ Aft	Streets	Directions street name field—Suffix Type
Func Class	Streets	Hierarchy attribute
Speed Cat	Streets	Can be used to calculate street travel time attribute
Dir Travel	Streets	Restriction attribute for one-way streets
L Area ID	Streets	Can be used to determine boundary field value
R Area ID	Streets	Can be used to determine boundary field value
AR Auto	Streets	Vehicle-specific street restriction attribute
AR Bus	Streets	Vehicle-specific street restriction attribute
AR Taxis	Streets	Vehicle-specific street restriction attribute
AR Carpool	Streets	Vehicle-specific street restriction attribute
AR Pedest	Streets	Vehicle-specific street restriction attribute
AR Truck	Streets	Vehicle-specific street restriction attribute
AR Traff	Streets	Vehicle-specific street restriction attribute
AR Deliv	Streets	Vehicle-specific street restriction attribute
AR EmerVeh	Streets	Vehicle-specific street restriction attribute
Paved	Streets	Restriction attribute for avoiding unpaved roads
Private	Streets	Restriction attribute for avoiding private roads
Tollway	Streets	Restriction attribute for avoiding toll roads
Z Level	Zlevels	Endpoint elevation field
AR Auto	Cdms	Vehicle-specific street and turn restriction attribute
AR Bus	Cdms	Vehicle-specific street and turn restriction attribute
AR Taxis	Cdms	Vehicle-specific street and turn restriction attribute
AR Carpool	Cdms	Vehicle-specific street and turn restriction attribute
AR Pedest	Cdms	Vehicle-specific street and turn restriction attribute

Field	Data Layer	Usage in the Network Dataset
AR_Truck	Cdms	Vehicle-specific street and turn restriction attribute
AR_Traff	Cdms	Vehicle-specific street and turn restriction attribute
AR_Deliv	Cdms	Vehicle-specific street and turn restriction attribute
AR_EmerVeh	Cdms	Vehicle-specific street and turn restriction attribute

Tele Atlas's Dynamap®/Transportation 7.0—ArcView Format

Field	Data Layer	Usage in the Network Dataset
PREFIX	Street	Directions street name field—Prefix
NAME	Street	Directions street name field—Name
TYPE	Street	Directions street name field—Suffix Type
SUFFIX	Street	Directions street name field—Suffix
ACC	Street	Hierarchy attribute
SHIELD	Street	Directions shield field—Shield Type
HWY_NUM	Street	Directions shield field—Shield Number
SEG_LEN	Street	Street length attribute
ONE_WAY	Street	Restriction attribute for one-way streets
F_ZLEV	Street	Endpoint elevation field
T_ZLEV	Street	Endpoint elevation field
FT_COST	Street	Street travel time attribute
TF_COST	Street	Street travel time attribute
TOLL	Toll	Restriction attribute for avoiding toll roads
COST	Maneuver	Turns travel time attribute

Tele Atlas's MultiNet™ 4.2—Shapefile Format

Field	Data Layer	Usage in the Network Dataset
METERS	Network	Street length attribute
NAME	Network	Directions street name field—Name
FRC	Network	Hierarchy attribute (North America)
NET2CLASS	Network	Hierarchy attribute (Europe only)
ROUTENUM	Network	Directions shield field—Shield Number
RTETYP	Network	Directions shield field—Shield Type
TOLLRD	Network	Restriction attribute for avoiding toll roads
PRIVATERD	Network	Restriction attribute for avoiding private roads
ONEWAY	Network	Restriction attribute for one-way streets
F_ELEV	Network	Endpoint elevation field
T_ELEV	Network	Endpoint elevation field
MINUTES	Network	Street travel time attribute
RESTRTYP	Restrictions	Restriction attribute for restricted streets, intersections, and turns



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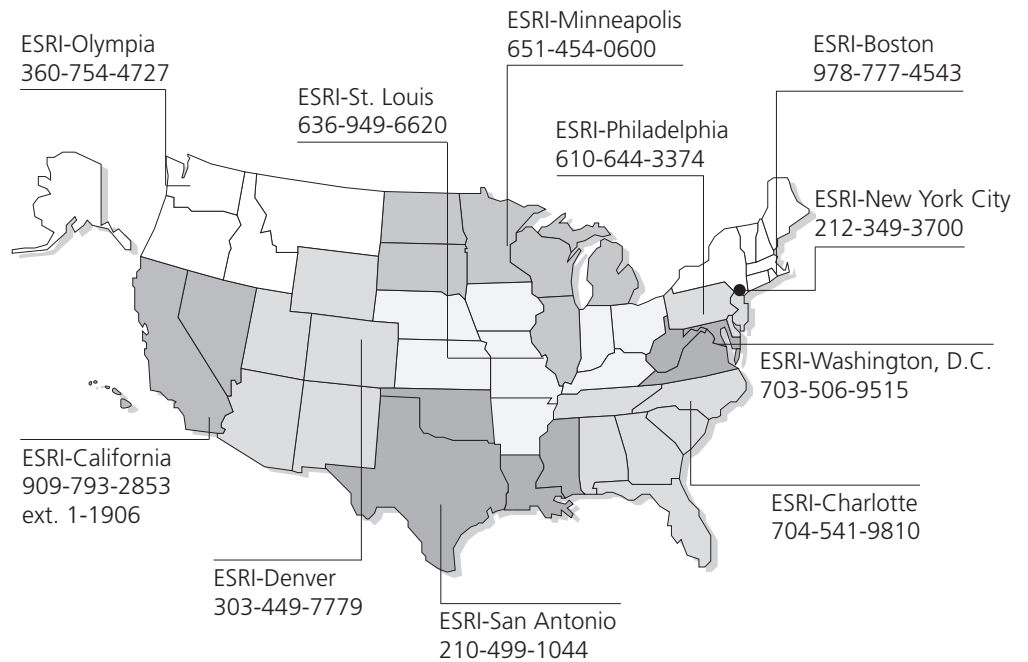
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