Proximity Exercise: Exploring Nuclear Power Plant Risk Zones in Southern New England

Written by Barbara Parmenter, revised 11/7/2014 by Carolyn Talmadge

Introduction

In this exercise, we'll be doing a simple analysis of the population at risk around New England's four nuclear power plants and exploring potential evacuation centers and routes. You'll practice using the following tools:

- Select by location
- Statistics
- Spatial Join
- Buffer and multi-ring buffer
- Near tool
- Point distance tool
- Network analysis – service area

Data Sets and Sources

The data sets have been acquired and pre-processed as described below. New England states refer to Connecticut, Rhode Island, Massachusetts, Vermont, and New Hampshire. **Directions on how to access the data are in the next section.**

Northeast_states_UTM19N

Data Source: Mapcruzin.com (http://www.mapcruzin.com/nuclear-power-plant-earthquake-shapefiles/), US basemap.zip, downloaded 3/30/2011.
Processing: The five New England states plus New York were selected out and exported to the UTM WGS 1984 Zone 19N coordinate system

Nuclear_Power_Plants_UTM19N

Data Source: Mapcruzin.com (http://www.mapcruzin.com/nuclear-power-plant-earthquake-shapefiles/), downloaded 3/30/2011.
Processing: The four New England power plants were selected out and exported to the UTM WGS 1984 Zone 19N coordinate system

Airports_UTM19N

Data source: Bureau of Transportation Statistics, National Transportation Atlas Database, 2010 (http://www.bts.gov/publications/national_transportation_atlas_database/2010/), downloaded 3/30/2011
Processing: Airports in the 5 New England states were selected and exported to the UTM WGS 1984 Zone 19N coordinate system

National_Highway_Planning_Network_UTM19N

Data source: Bureau of Transportation Statistics, National Transportation Atlas Database, 2010 , NHPN, Region 1 (http://www.bts.gov/publications/national_transportation_atlas_database/2010/), downloaded 3/30/2011
Processing: The roads and highways were exported to the UTM WGS 1984 Zone 19N coordinate system

EPA_region1_schools_UTM19N

Data source: EPA Region 1 public schools, accessed via Geodata.gov (http://gos2.geodata.gov/wps/portal/gos), published 2008, downloaded 3/30/2011
Processing: Schools were exported to the UTM WGS 1984 Zone 19N coordinate system

2000_blockpop_centroids_UTM19N

Data source: ESRI, Census 2000, M:\\ESRIDataMaps93\Census\Blockpop.shp
Processing: Census block points within southern New England, eastern New York and Long Island were selected graphically and exported to the UTM WGS 1984 Zone 19N coordinate system

> **Important attribute column names note:**
> Pop2000 – 2000 Census population count
> HSE_Units – 2000 Census housing unit count
> Household – 2000 Census household count (a household = people sharing one housing unit)

Hospitals_UTM19N

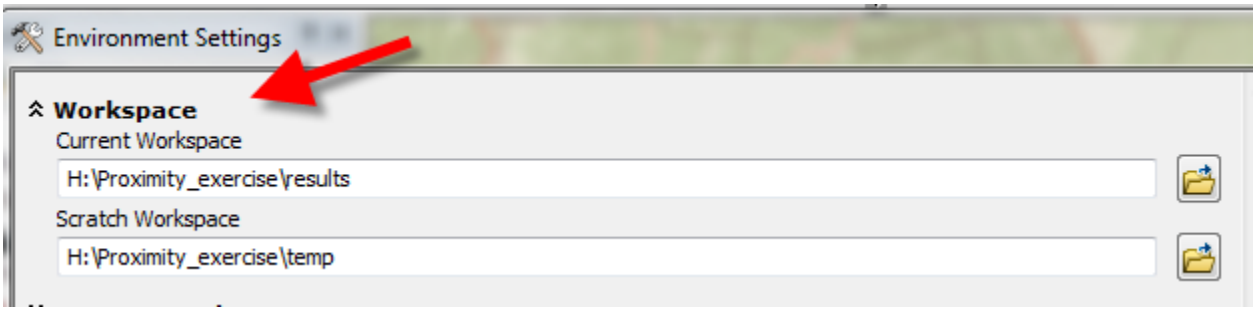
Data Source: US Department of Health and Human Services , HRSA Geospatial Data Clearinghouse – ArcIMS Server: datawarehouse.hrsa.gov, Service Name: HGDW_Mapping (ArcGIS directions can be found here: http://datawarehouse.hrsa.gov/HGDWFeatureService.aspx)
Processing: All US Hospitals were exported out of the ArcIMS server, then the hospitals in the 5 New England states were selected and exported to the UTM WGS 1984 Zone 19N coordinate system.

> **Important attribute table column names note:**
> HRSAgeo_5 = provider category code

HRSAgeo_6 = provider category description
HRSAgeo_7 = category sub-type code
HRSAgeo_8 = provider category sub-type description
HRSAgeo9 = Facility Name
HRSAgeo10 = Total Bed Count
HRSAgeo_11 = certified bed count

Accessing and Preparing for the Tutorial

1. From *S:\classes\DHP_P207* copy the **Proximity_Exercise** folder to your H: drive or Desktop (the rest of the exercise assumes H: drive, so just substitute desktop folder path if you are doing it there).
    a. You can also download the data from the link on the Tufts' GIS website.
2. Open the **Proximity_Exercise** folder and double-click on **Start_map.mxd** – this will start ArcMap.
3. In ArcMap, go to **Customize – Extensions** – and checkmark *Spatial Analyst* and *Network Analyst*
4. Take a couple minutes to explore the different data layers – look at their attribute tables especially.
5. Click on **Geoprocessing – Environments…**
6. In the Environment Settings box, click on Workspace
7. Set the **Current Workspace** to be your *Proximity_Exercise/Results folder* and your **Scratch Workspace** to *Proximity_exercise/Temp folder* (read about the difference by clicking tool help, and search for "scratch space" in the search tab on the upper left):



Select by Location - population estimations in 12 and 50 miles zones around the four nuclear plants

Using tools you already know, how would you estimate the population within a 12 mile (20km) zone of Southern New England's four nuclear power plants? (Hint: Select by location, statistics)

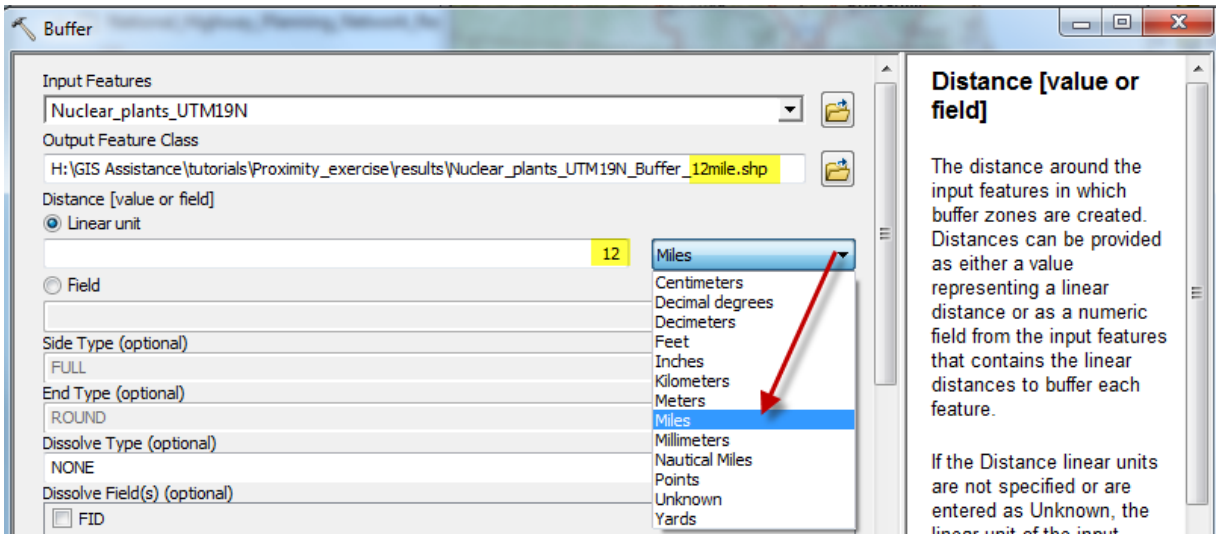
How many households are there? How many housing units? Why might we want to know population, households, and housing units, rather than just one of these numbers?

Estimate the population with a 50 mile zone.

Buffer Tools - Visualizing a 12 mile and 50 mile evacuation zone

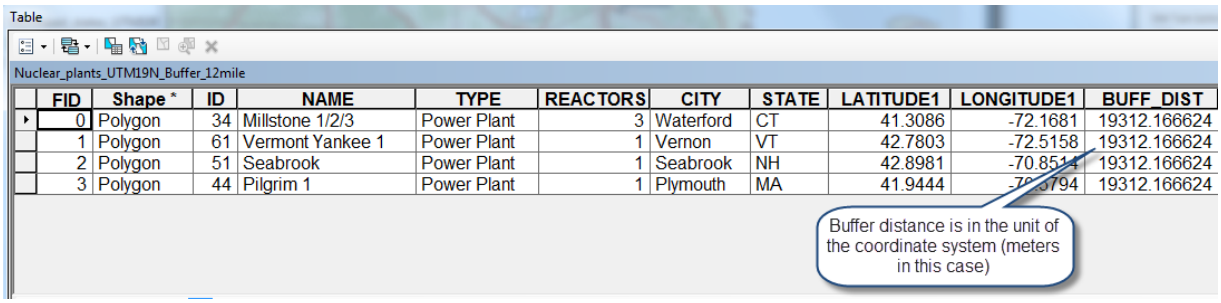
Buffers can help us visualize zones and perform further analysis.

1. Click on the **ArcToolbox** icon  to open it, or scroll down your Catalog window to the System Tools:
2. Go to **Analysis Tools – Proximity** - you see **Buffer** and **Multiple Ring Buffer**
3. Double-click on **Buffer**
4. Click **Show Help –** the help is context sensitive so when you click in a box, it will tell you what to do
5. Fill out the dialog box as you see here (using your personal folder path), making sure to include "12_mile" in the new file name:



6. Press OK
7. When the processing is complete, click Close and if prompted, view the results on your map. (The buffer layer you just created may appear automatically in your table of contents.)
8. Click on **File – Save As** and save your mapfile to *Proximity1.mxd*
9. You can set the 12-milebuffer zones to be transparent by right-clicking on the buffer data layer and going to *Properties – Display*.

10. Open the attribute table of the new buffer data layer. What do you see?



FID	Shape *	ID	NAME	TYPE	REACTORS	CITY	STATE	LATITUDE1	LONGITUDE1	BUFF_DIST
0	Polygon	34	Millstone 1/2/3	Power Plant	3	Waterford	CT	41.3086	-72.1681	19312.166624
1	Polygon	61	Vermont Yankee 1	Power Plant	1	Vernon	VT	42.7803	-72.5158	19312.166624
2	Polygon	51	Seabrook	Power Plant	1	Seabrook	NH	42.8981	-70.8514	19312.166624
3	Polygon	44	Pilgrim 1	Power Plant	1	Plymouth	MA	41.9444	-70.5794	19312.166624

The difference between a dissolved buffer and a non-dissolved buffer

You chose NONE for Dissolve Type when you created your buffer. This creates a separate buffer around each plant. If you choose DISSOLVE, all your buffers are one feature and the attribute information of the nuclear power plants would be lost. By keeping the Dissolve Type option set to none, you have the four buffer features, with the associated nuclear power plant information.

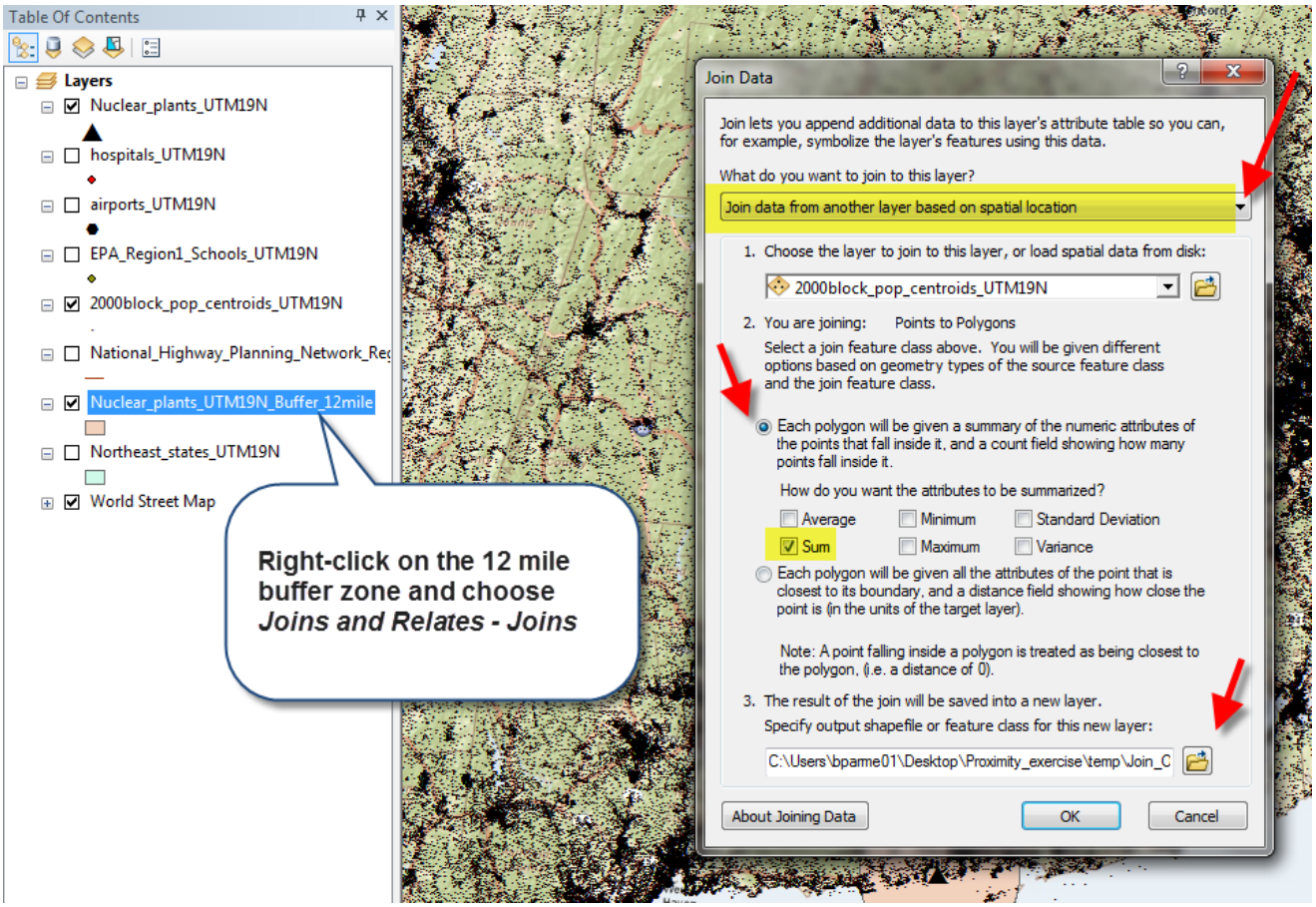
If you wanted to create a 50 mile zone around each plant, you could repeat the buffer process and specify 50 miles.

We will base the rest of our analysis on the 12 mile zones, so turn on the 12 mile buffer.

Performing a spatial join to estimate the population with 12 miles of each nuclear power plant

If we want to the population within 12 miles of each nuclear power plant, we could select each plant one at a time, and then select all the 2000 blockpop centroids within 12 miles of the selected plant, then look at the attribute table. And do this individually for each plant.

Or we can use a function called a spatial join, which makes it much easier. Follow the graphic on the next page, and call the output file **12_mile_buffer_with_2000_Population_Estimates.shp**:



Explore the resulting attribute table of the **12 mile buffer with 2000 Population Estimates.shp.** The sum of population and households and housing is at the far left end of the table.

12_mile_buffer_with_2000_Population_Estimates

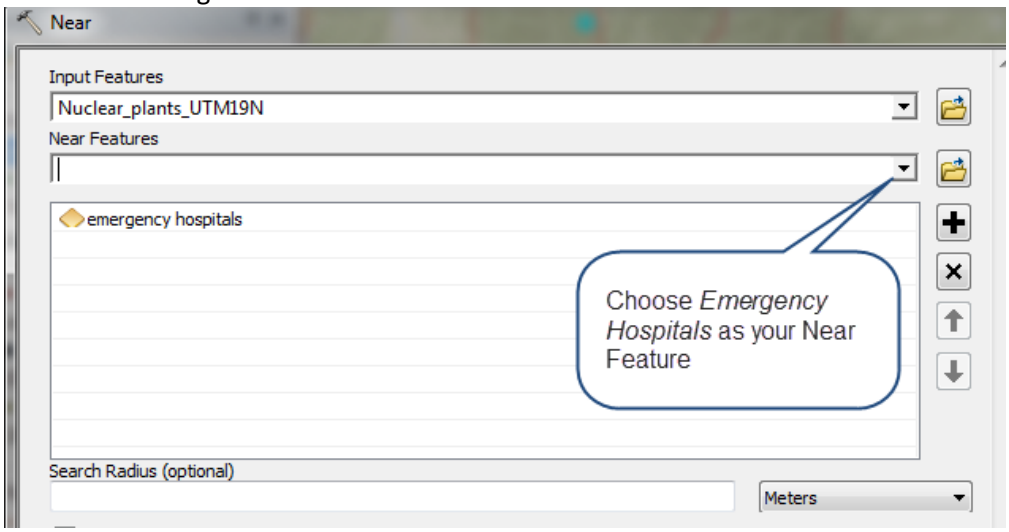
NAME	Sum_POP200	Sum_HSE_UN	Sum_HOUSEH
Millstone 1/2/3	146294	63948	56104
Vermont Yankee 1	43557	19201	17621
Seabrook	146017	64814	57994
Pilgrim 1	102805	41375	36752

NEAR tool – what is the nearest hospital to each nuclear plant and how many beds does it have? (as the crow flies!)

We now want to know the nearest hospital to each nuclear plant and how many beds it has for emergency training and planning purposes.

1. Turn on Hospitals and look at its attribute table. Which type of hospital would be good to serve as a medical provider in the event of an emergency at a nuclear plant? (*HRSAgeo_8* has the hospital sub-type description)

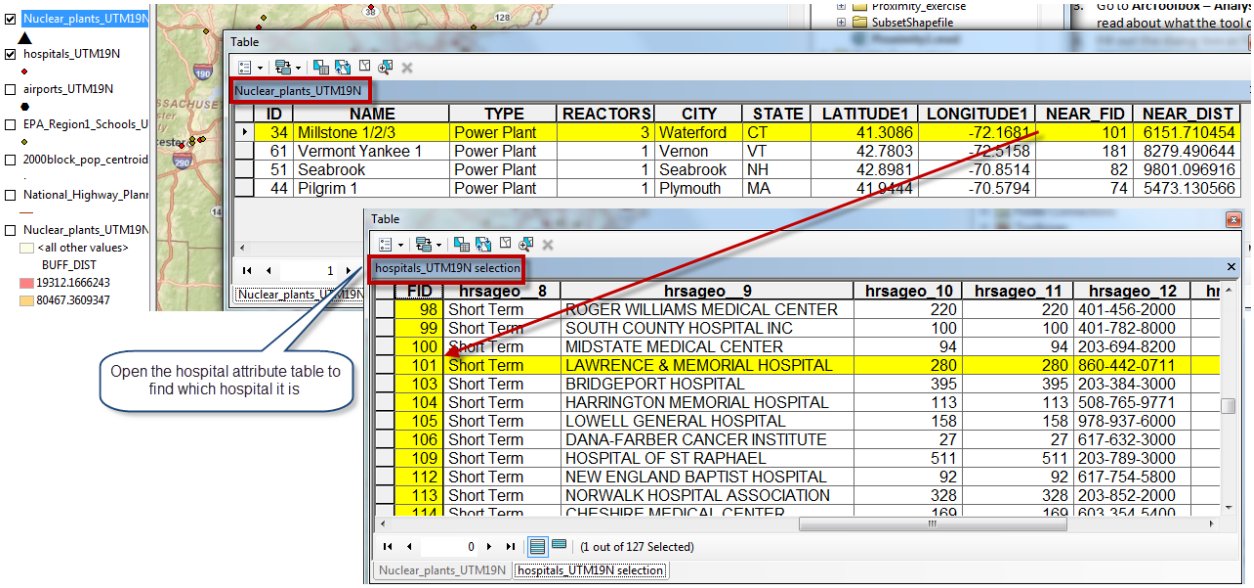
2. Use **Select by Attribute** to select for those types of hospital
3. Create a **new layer selection** from the selected hospitals and call it *Emergency Hospitals*
4. Go to **ArcToolbox – Analysis Tools – Proximity** and double-click on **NEAR** – make sure to *Show Help* and read about what the tool does.
5. Fill out the dialog box as follows:



6. Click OK
7. This function adds two new fields to your **Nuclear Plant attribute table** – open that table to see. Scroll towards the right of the table. You see NEAR_FID and a NEAR_DIST. The Near_FID is the Feature ID of the nearest hospital. The Near_Dist is the distance (straight line) to the nearest hospital. Note the near_distance is given in the unit of the coordinate system, so meters in this case.

NAME	TYPE	REACTORS	CITY	STATE	LATITUDE1	LONGITUDE1	NEAR_FID	NEAR_DIST
Millstone 1/2/3	Power Plant	3	Waterford	CT	41.3086	-72.1681	101	6151.710454
Vermont Yankee 1	Power Plant	1	Vernon	VT	42.7803	-72.5158	181	8279.490644
Seabrook	Power Plant	1	Seabrook	NH	42.8981	-70.8514	82	9801.096916
Pilgrim 1	Power Plant	1	Plymouth	MA	41.9444	-70.5794	74	5473.130566

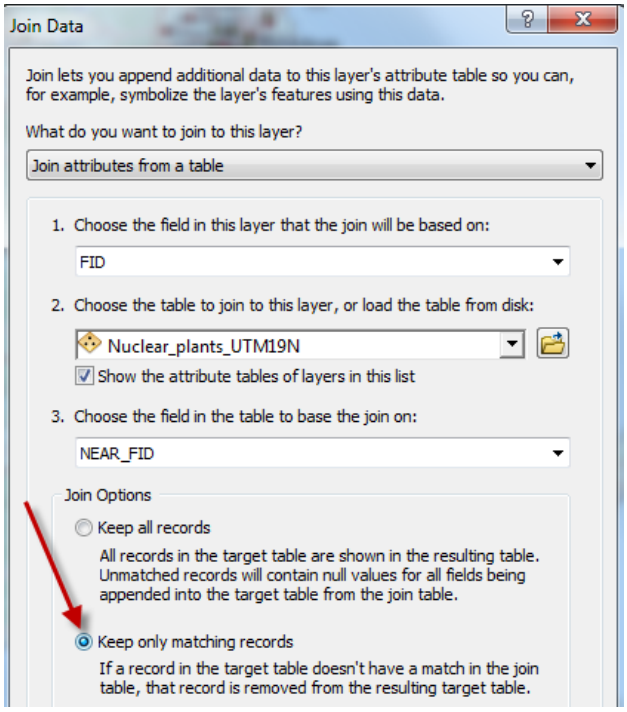
8. If we open up the **Emergency Hospitals** table, you'll see the FID at the very beginning of the table. In our case (given the types of hospitals we selected), if you look at the Nuclear Plant table, we find the nearest hospital to the Millstone Power Plant in Waterford, CT, is the Lawrence and Memorial Hospital. (Your results may be different based on your hospital type selection). See the next page for a graphic of this:



Note that *HRSAgeo_10* = bed count, so we know that the Lawrence & Memorial Hospital in New London is the closest of the hospitals we selected and that it has 280 beds.

Since we now have a common attribute field between the two data layers (FID in Hospitals and NEAR_FID in our Nuclear plants, we could perform a table join to see them.

Right-click on the **Emergency Hospitals** layer and **choose Joins and Relates – Join** and fill in the box as follows:



If prompted to create index, click yes.

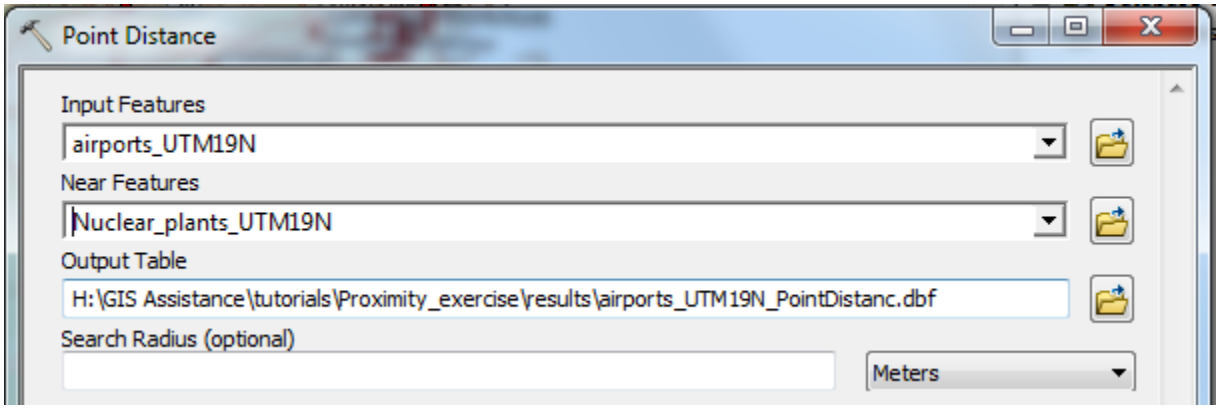
Save your map!

What if we want to know the closest hospitals outside the 12 mile zone? Can you think of a solution for this problem using tools you know? (Hint: one approach would be to select by location for all emergency hospitals within 12 miles, then switch selection to all other hospitals, then use NEAR on the selected emergency hospitals. You can find *switch selection* if you right click on the selected Emergency Hospitals, and go to *Selection – Switch Selection*.

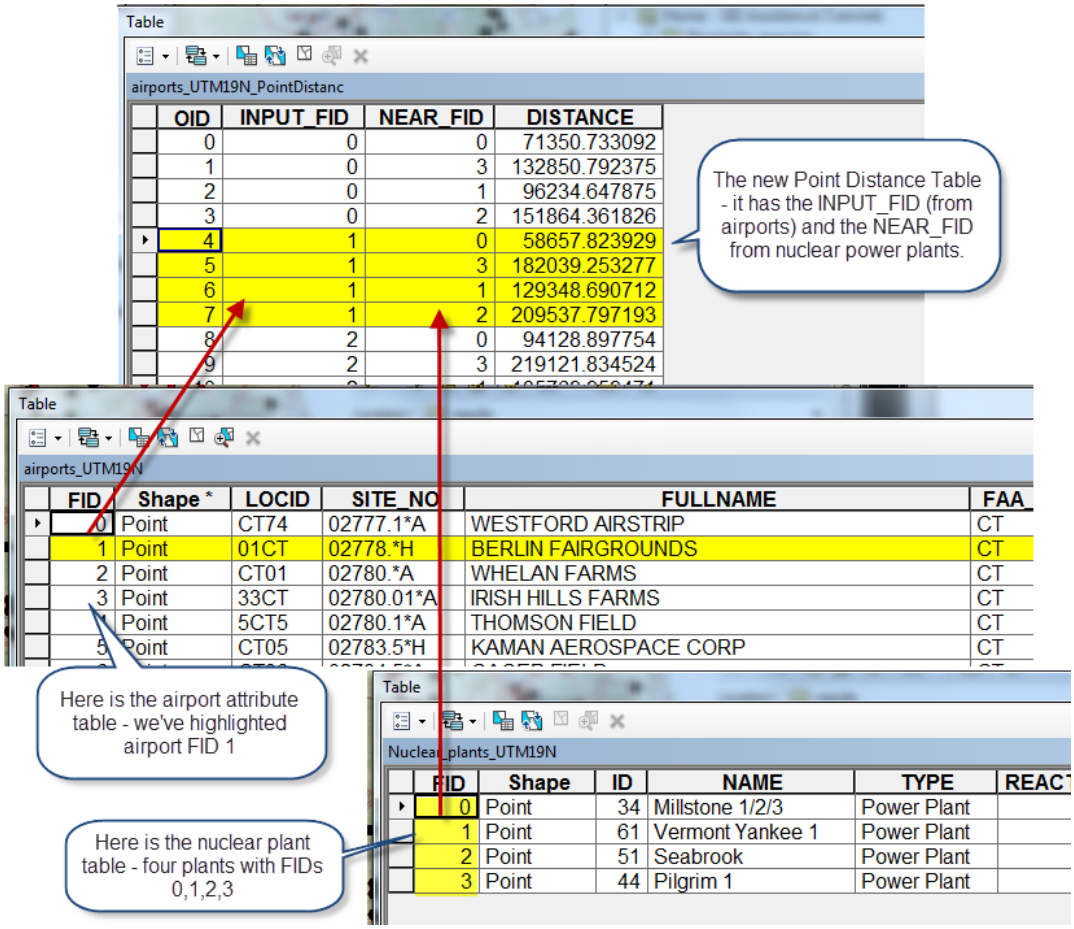
Point distance tool – find the distance from all airports to all four nuclear plants

Because we may have to use multiple airports to respond to a crisis, we'd like to know how far all the airports in New England are to all the nuclear power plants. The POINT DISTANCE tool will calculate the distance from all points in one layer to all points in another layer.

1. Clear any selections you have.
2. Go to **ArcToolbox – Analysis – Proximity** and double click on the **POINT DISTANCE** tool.
3. Fill in the dialog box as follows – note that the result will be a .dbf database table – remember the name and location!



4. Click OK and once is completed click Close on the new window.
5. Open the new table. You'll see the INPUT_FID which is the FID of the Airport and the NEAR_FID which is the FID of the Nuclear Power Plant (you can open those tables to see if you like or just look at the graphic on the next page) – again the distance is in meters. See the graphic on the next page for guidance.



From this new point distance table you could run a query in an emergency to find all the airports within a certain distance of a specific nuclear power plant. What would you need to do to find the distances of all airports to the Pilgrim 1 Station in Plymouth? This is tricky! Because each airport record is repeated four times, once for each of the four power plants, you'd first have to select out all the airport records for Near_FID = 3 (Pilgrim). Then you would export this to its own table (e.g., *Pilgrim_airport_distances)*. In that table the airport records are not repeated – that is there is a unique airport record on each row. Now the exported table can be joined back to the Airports table using the FID in Airports and the Input_FID from *Pilgrim_airport_distances* table.

Save your map again!

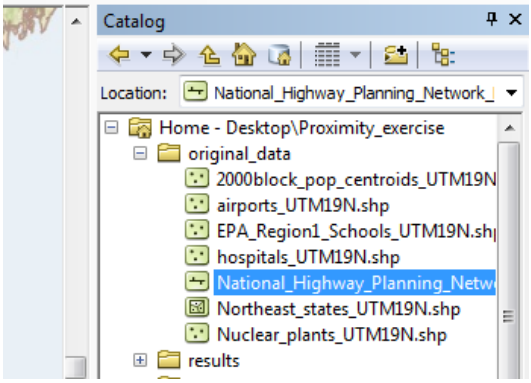
OPTIONAL: Network analyst – service area analysis - Visualize a 50 mile drive from each Nuclear Power Plant

We want to be able to visualize what response and relief resources are **within a 50 mile drive** of our nuclear power plants. The "as the crow flies" buffer (Euclidean distance) will not do this for us. But the **Network Analyst** extension has the functions we need.

This analysis is unfriendly in terms of the user interface but not difficult to do – we'll do it together in class but there are the basic steps.

Create the network data set in ArcCatalog

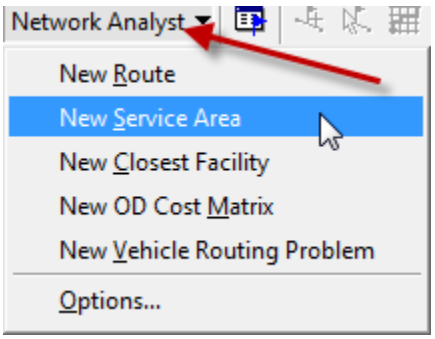
1. Enable the **Network Analyst** extension if not already enabled (**Customize – Extensions**)
2. Open ArcCatalog as a Window in ArcMap if you haven't already (choose **Windows – Catalog**)
3. Navigate to your proximity practice folder and find the **National_Highway_Planning_Network_UTM19N**



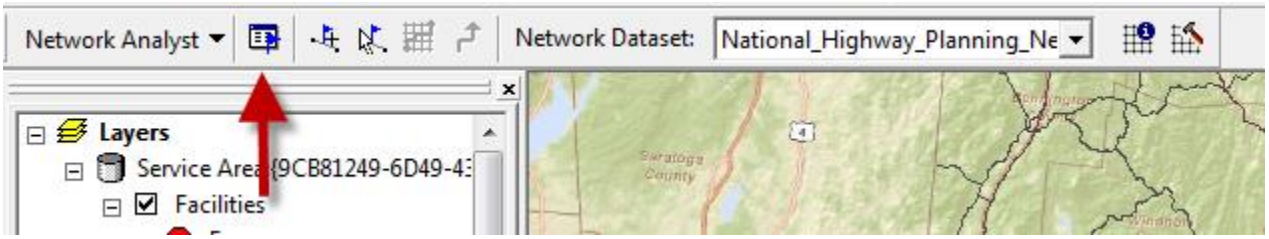
4. Right –click on that data set and choose the option for **New Network Data Set**
5. Accept all the defaults by clicking Next, except click **NO** for driving directions. Hit the Finish button, and finally say **Yes** to building the network dataset.
6. Also say **Yes** to adding it to your map.
7. Turn off the junction points layer (National_Highway_Planning_Network_Region1_UTM19N_Junctions). Leave the Edges on – this is your network data set.

Performing the Service Area Analysis in ArcMap

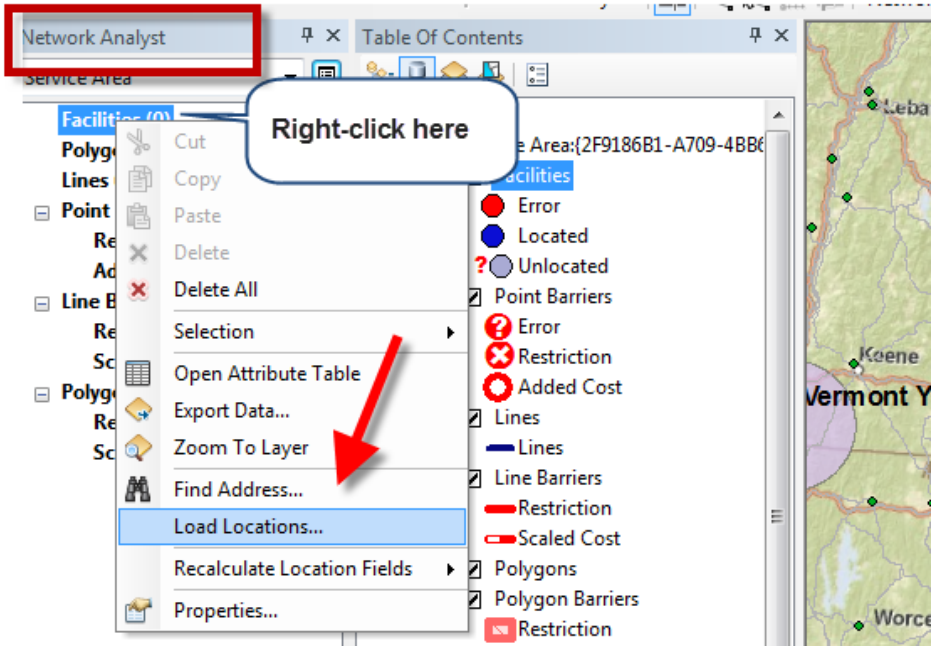
1. Go to **Customize – Toolbars** and check mark the **Network Analyst** toolbar.
2. From the **Network Analyst** toolbar choose *New Service Area*:



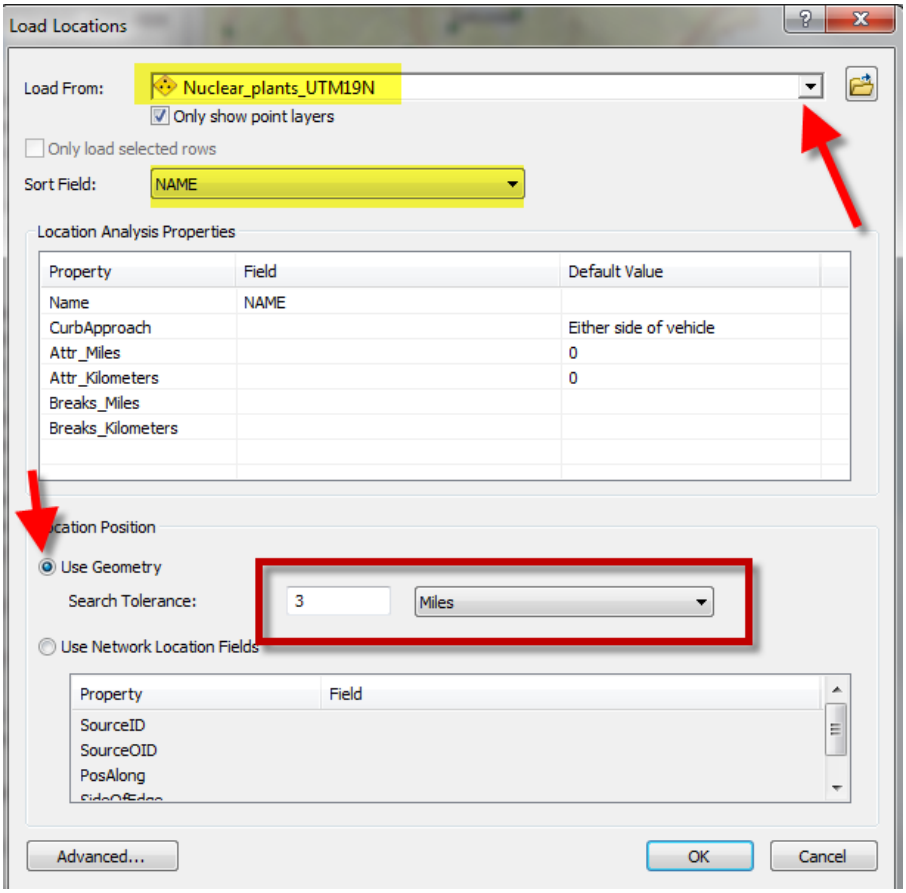
3. From the **Network Analyst** toolbar, click *on Network Analyst Window* (a new window to the left of the Table of contents will appear).



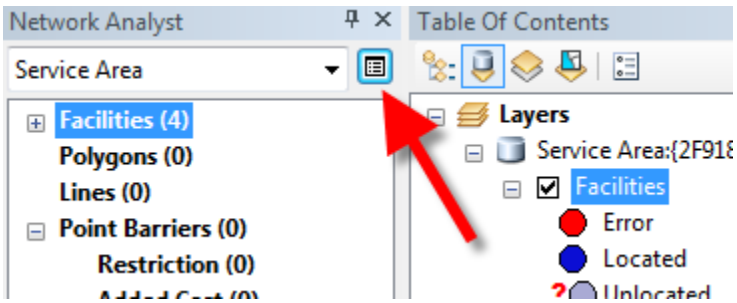
4. In the new **Network Analyst Window**, right-click on *Facilities* and choose *Load Locations* – these will be our Nuclear Power Plants:



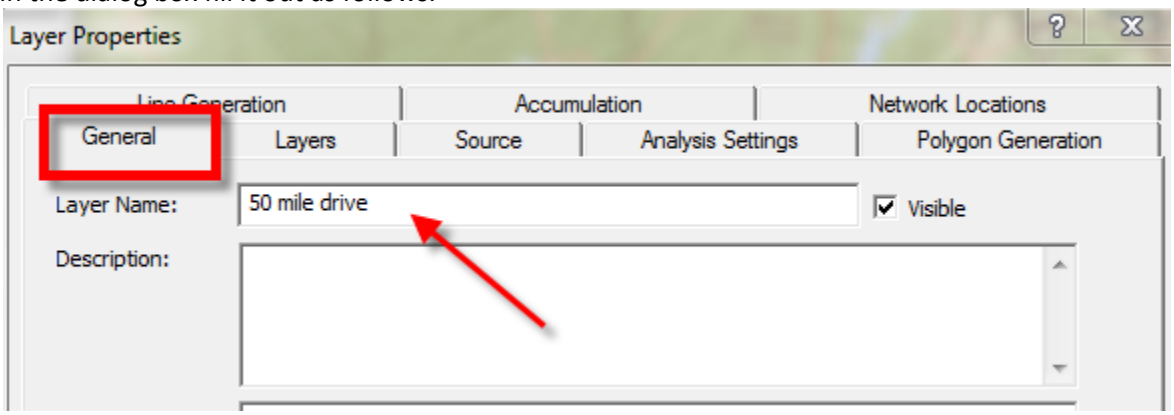
5. Fill out **the Load Locations** dialog box as follows:

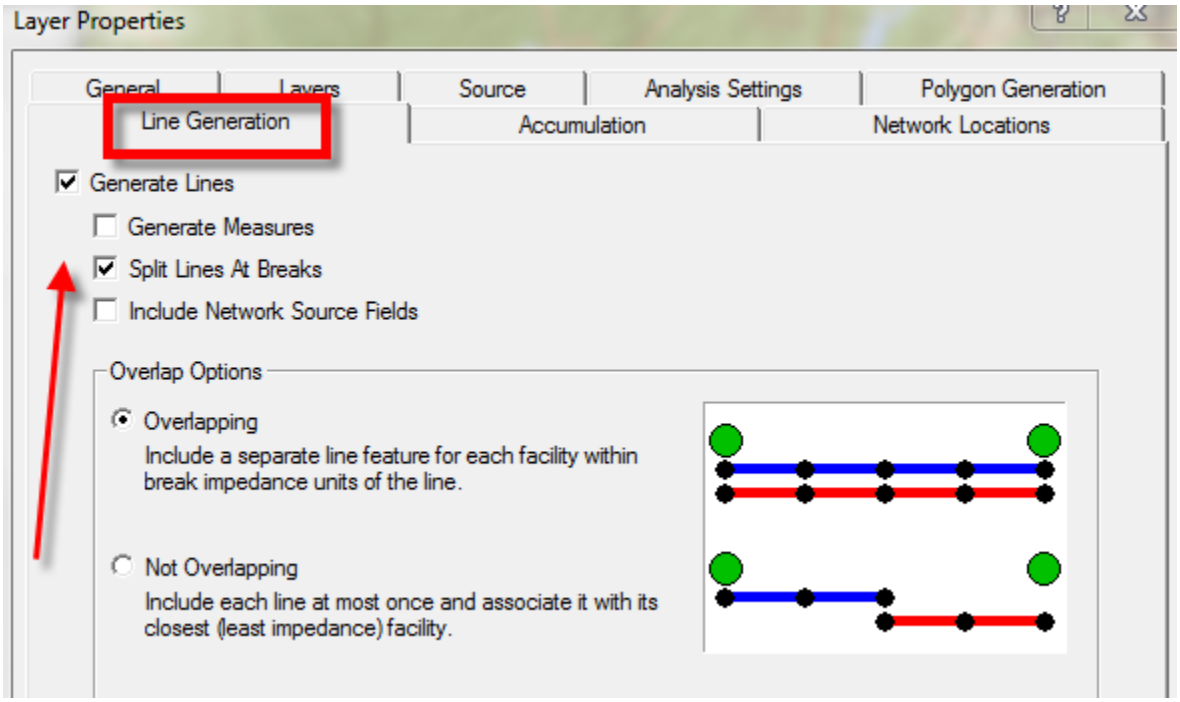


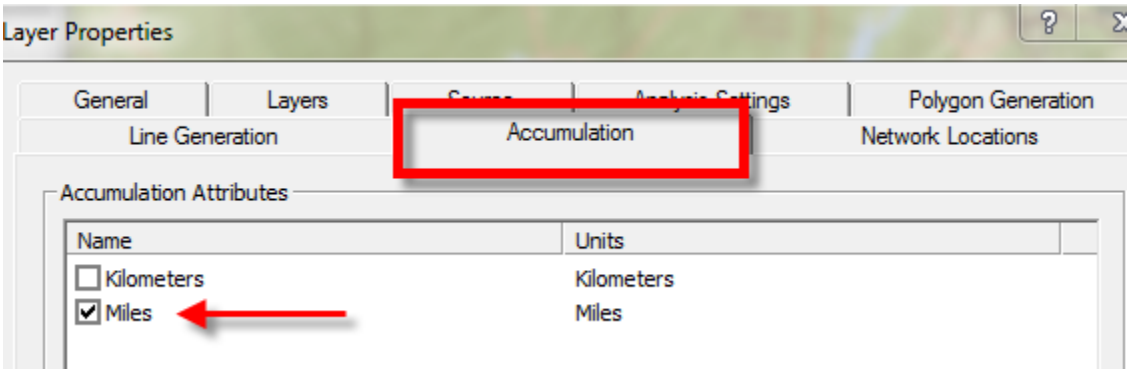
6. Press OK
7. You should have 4 facilities located (the four nuclear plants). Click on the **Service Areas Properties** box:

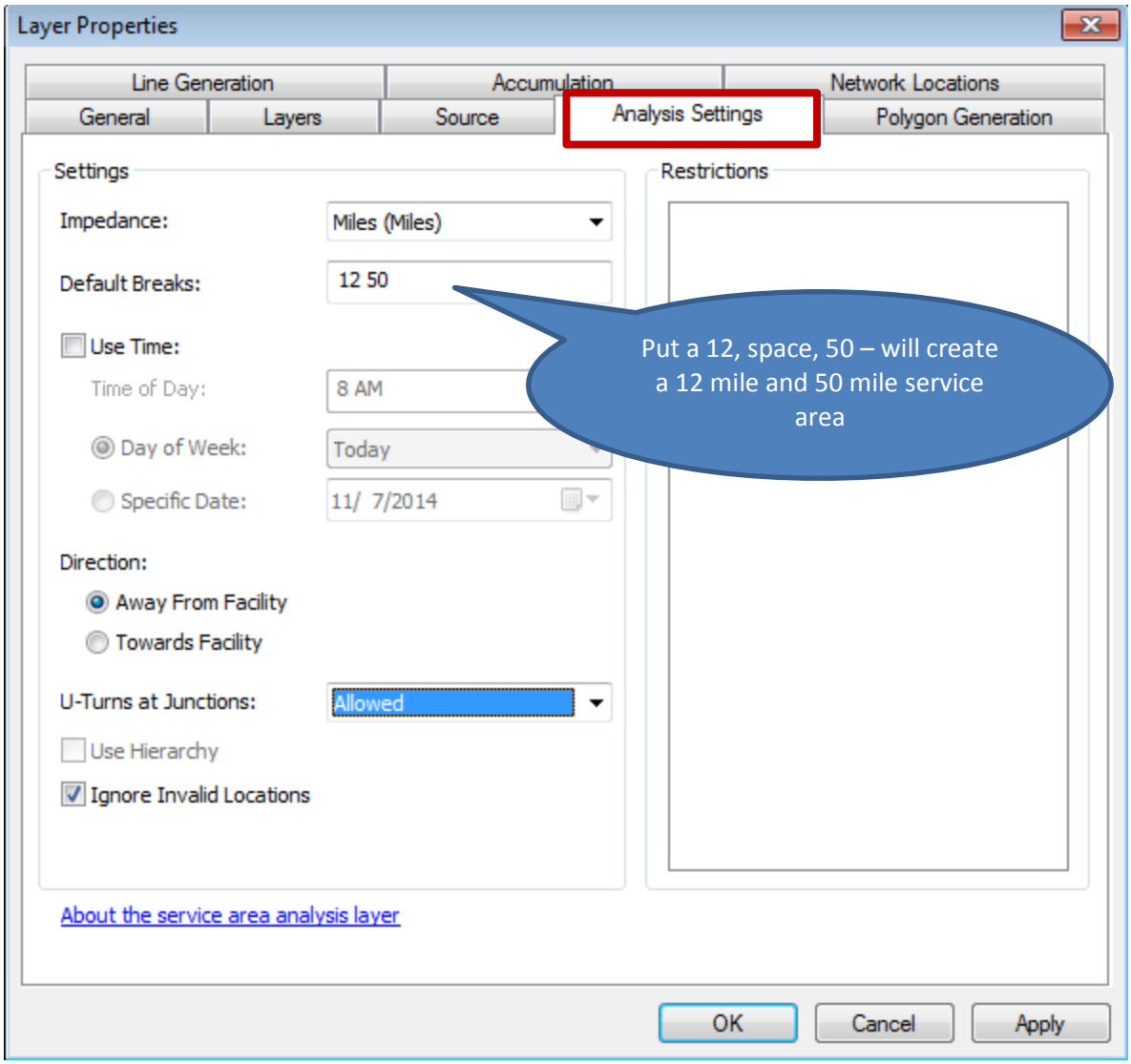


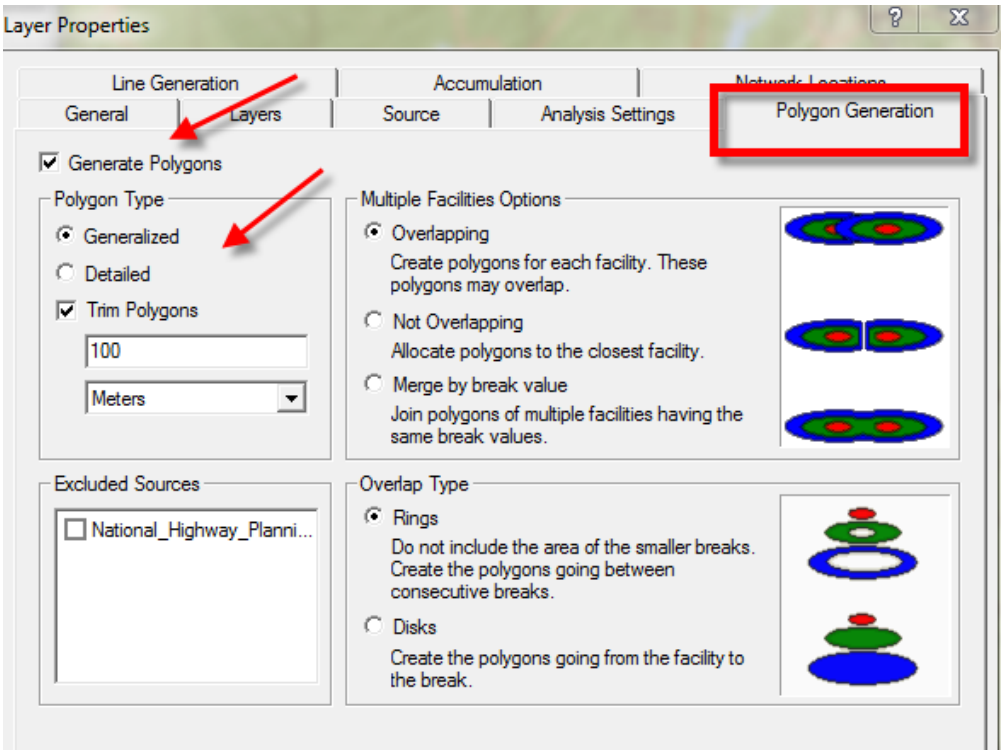
8. In the dialog box fill it out as follows:



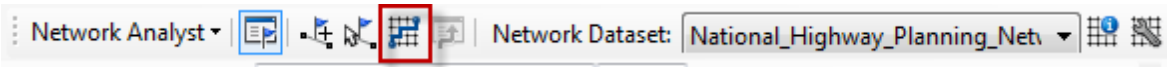




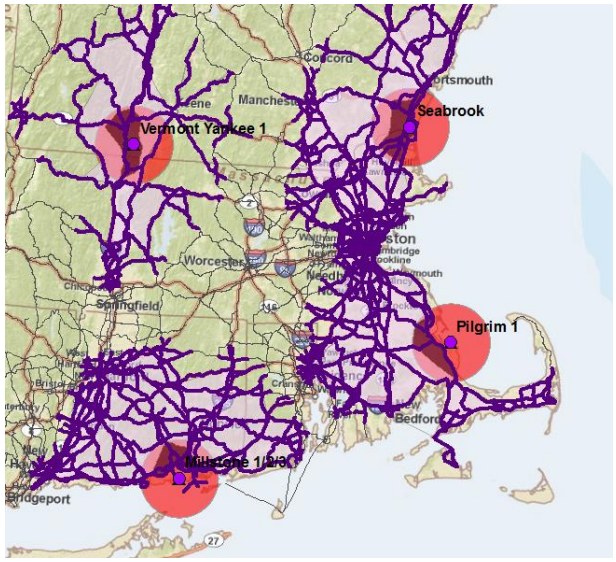

Layer Properties
Line Generation
Accumulation
Network Locations
General
Layers
Source
Analysis Settings
Polygon Generation
Settings
Impedance:
Miles (Miles)
Default Breaks:
12 50
Use Time:
Time of Day:
8 AM
Day of Week:
Today
Specific Date:
11/ 7/2014
Direction:
Away From Facility
Towards Facility
U-Turns at Junctions:
Allowed
Use Hierarchy
Ignore Invalid Locations
Restrictions
About the service area analysis layer
OK
Cancel
Apply
Put a 12, space, 50 – will create a 12 mile and 50 mile service area



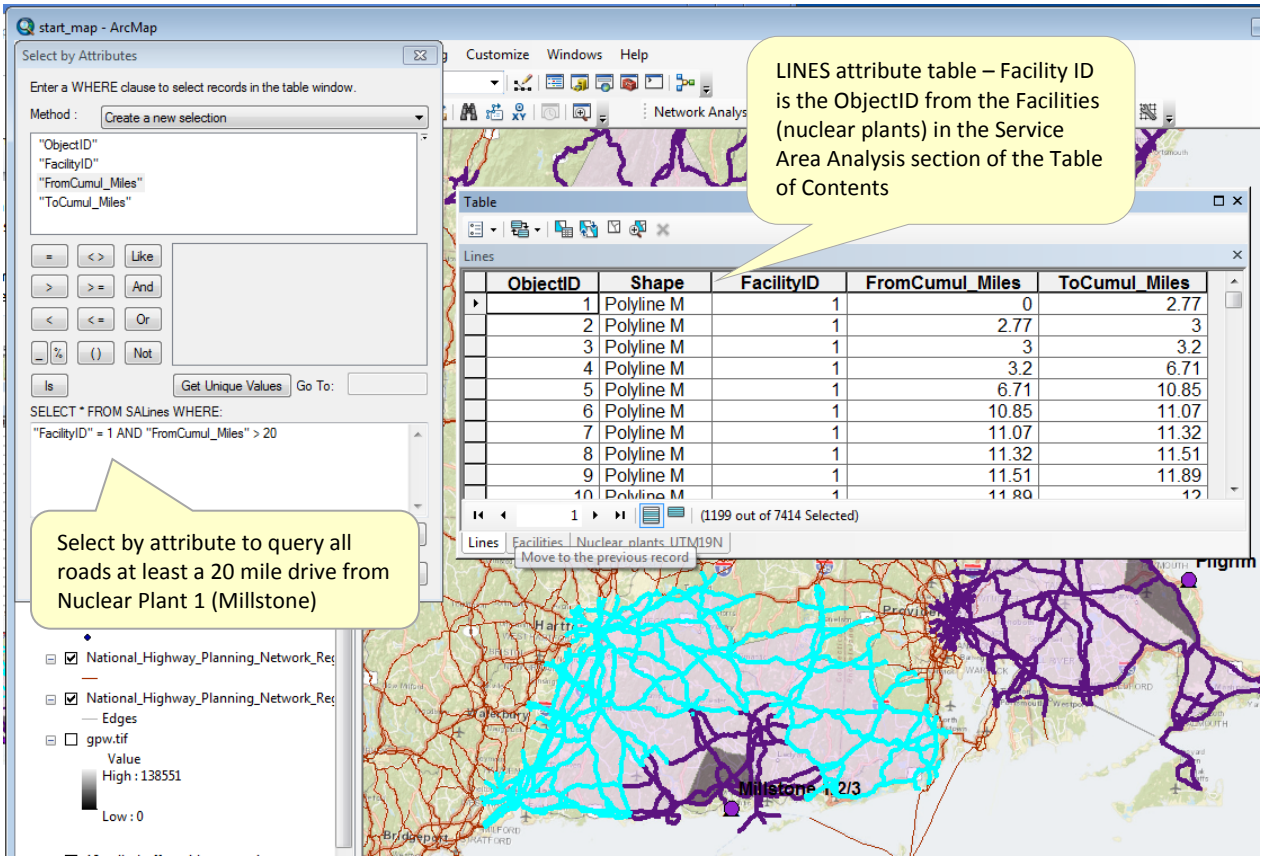
9. That's it! Click OK. Nothing happens yet!
10. Now click on the **SOLVE** icon



11. Your map should now look something like this – the purple roads and light purple zone is within a 50 mile drive of a powerplant:



12. You can turn on hospitals, schools or airports to visualize where potential resources are within these zones. Or you can select them by whether they are inside the zones, or close to roads within the zones, etc.
13. Explore the attribute tables for **Lines** in the **Service Area Analysis** area of the *Table of Contents* – note you can do things like select for all roads that are at least a 20 mile drive from a particular facility:



You could continue this analysis with tools you know. For example, what if we wanted to find all the high schools that are within a half mile of our selected highway lines from the Millstone plant above so that they could serve as relief centers in the case of a problem?

If you turn on your 12 and 50 mile multi-ring buffer – note that being 50 miles away by road is not the same as being 50 miles away in straight line distance!

The service area analysis is more typically used to find things like the streets within a walkable distance (e.g., ¼ mile) or a driving distance (e.g., 5 miles) of a service like a store or hospital.

That's enough for now. But we hope you see that using these kinds of tools you could manage a true geographic INFORMATION system that can help respond in an emergency and to plan for the unexpected.