GEOM90008 Foundations of Spatial Information

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ASSIGNMENT 2, MODULE 3: ROAD NETWORK ANALYSIS IN NORTHERN VICTORIA

1. OBJECTIVE

To obtain an understanding of network analysis by working through the road network dataset for Northern Victoria.

2. INTRODUCTION

Road networks are the key form of transport in Northern Victoria, a region characterized by extensive irrigation-based agriculture, small rural populations and large distances between towns. To help plan for future government services in Northern Victoria, a useful tool is the network analysis function now available in many GIS. In this exercise, you will use road network analysis to:

1) Calculate optimal road routes;
2) Find the closest facilities to nominated locations;
3) Calculate the facility service areas.

3. DATA REQUIRED

In this exercise, you will use road network data supplied by Spatial Information Infrastructure Victoria (the State government agency tasked with providing key land-related digital datasets for Victoria). You will require:

- zipped data from this directory – contains towns.shp, roads.shp, sites.shp and their corresponding files. The data can be found in LMS (NetworkAnalysis-data.zip).

4. PROCEDURE

4.1 Getting started

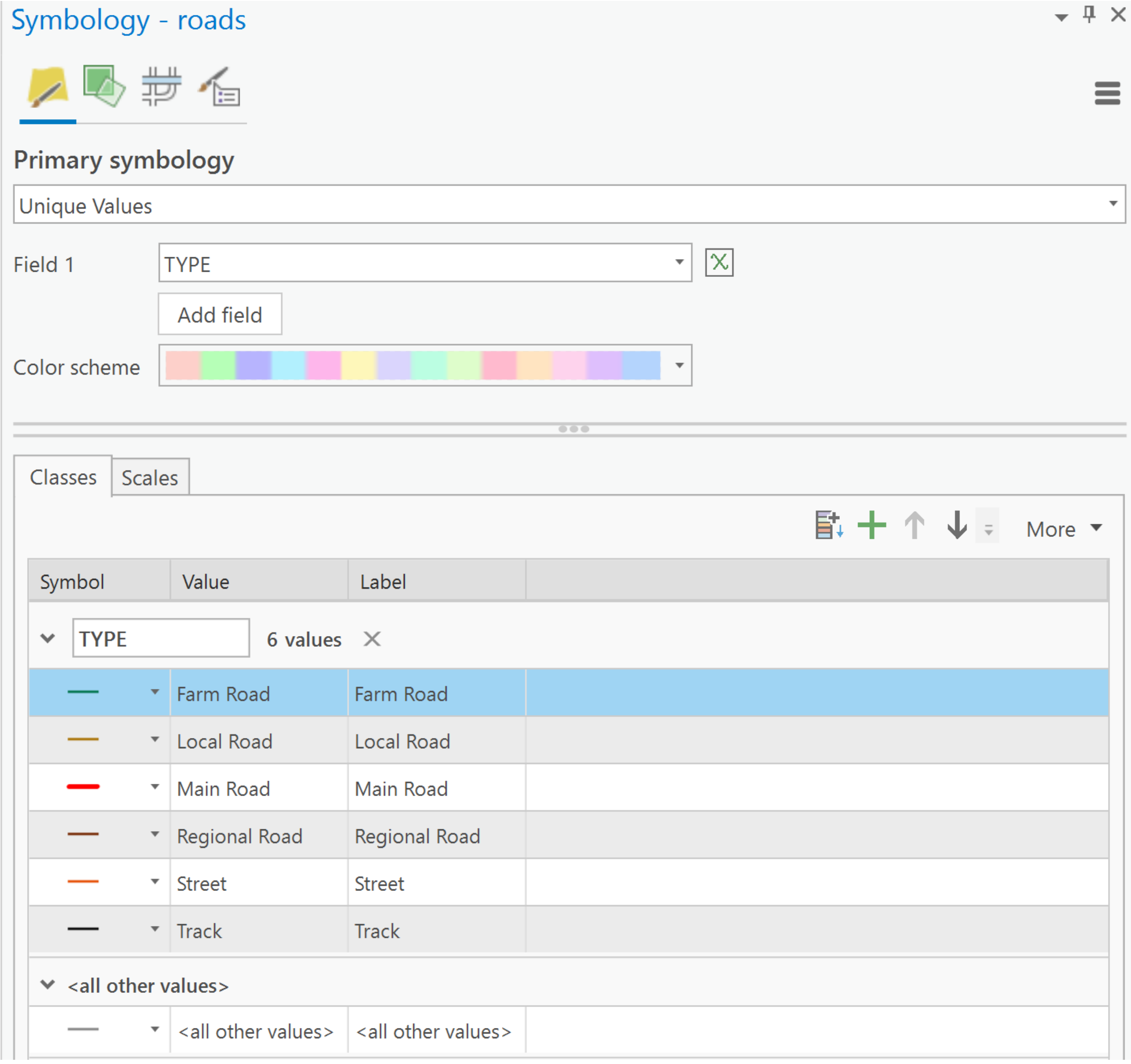
Ensure that the Network Analyst extension is switched on. There are two steps to this: File > Licensing > Esir Extensions.

4.2 Understanding the content of your data

Let's examine the data themes more closely.

Add the data (roads.shp, sites.shp and towns.shp) to your ArcGIS session using the 'Add data' button which you learnt about in the previous tutorial.

- Display the town's theme and right-click on towns layer and go to Symbology. Display single symbols for each town in the form of a blue star of size 16.
- Right-click on towns layer and select 'Label' to show labels for the towns based on the locality field (label field can be found by right click and select label properties). Alternatively, you could click on the layer and use the *Labelling ribbon*.
- Make the theme of the road active, display it, and use the 'Symbology' to display unique values for the different road classes occurring in the type field. (Hint: Unique Values Value field = Type and click Add All Values). Edit the symbol colours so that main roads are red and size 2 (thick lines), regional roads are dark brown, streets are red, local roads are mid-brown, farm roads are green, and tracks are black.

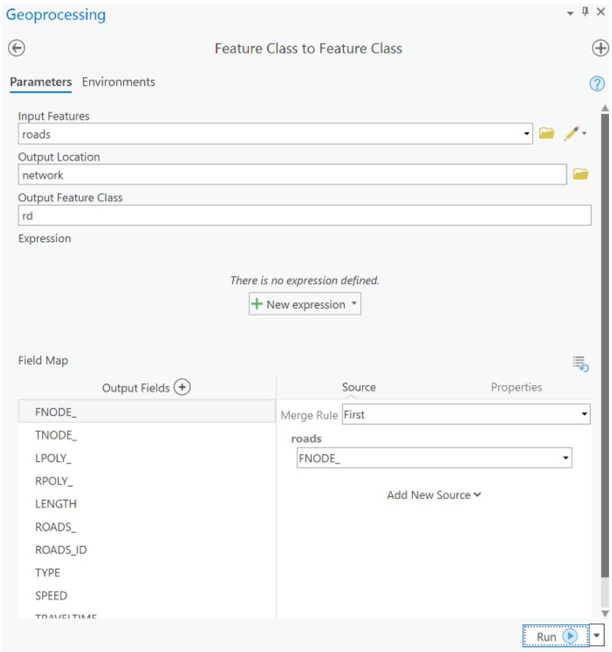


NOTE: The Eastern edge of the dataset indicates the approximate position of the Murray River – the border between New South Wales and Victoria.

4.3 Building a network dataset

Q1. The data structure in ArcGIS Pro: Can you tell, after this exercise, the relations among 1) geodatabase; 2) feature datasets; 3) feature classes?

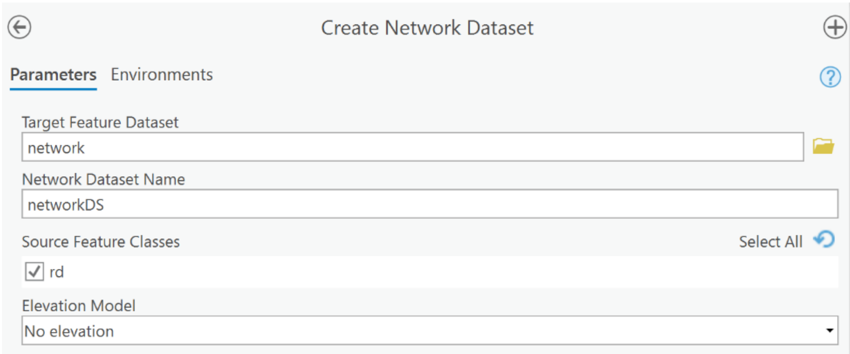
- Open Catalog pane – recall that Catalog takes charge of *creating* a dataset. First of all, you need to create a geodatabase to save the road network. You can *only* build a network dataset in a geodatabase (see appendix for details).
- Create a *feature dataset* (this is a collection of related feature classes you would like to work on, so one database can contain multiple datasets, and one dataset contain multiple feature classes) in the database by right-clicking the database > new feature dataset
- Import the road shapefile (which is a stand-alone file yet in a database) to the dataset in the targeted geodatabase by right-clicking the dataset> import file (road).
- Then create the *network dataset* (this is literally a "copy" of the imported road feature class but include more advanced important topological and other relevant analysis information specified by you and generated by the software).



4.3.1 Creating network dataset

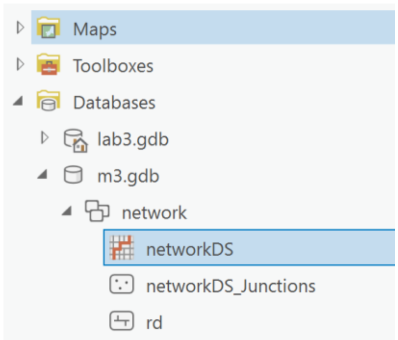
- Search for *Create Network Dataset* in the Geoprocessing pane.
- Select the feature dataset and tick road layer.
- Set the elevation model to *no elevation*.

- Click ‘Run’.



Note:

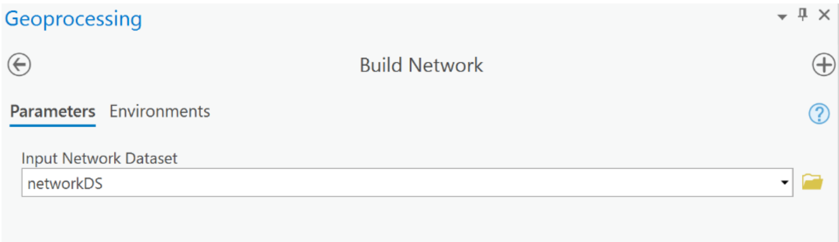
- When specifying the attributes for the new network dataset, *length (meters)* is the default cost attribute. If you want to specify other cost attributes (such as travel time in minutes) you can change these parameters in Catalog pane.
- To change parameters, go to Catalog pane and find the network dataset in the feature dataset.
- Right-click on network dataset and select properties.



- Select travel attribute and choose cost tab. Here, you can specify a different cost function. In this assignment, we use the default (length) cost function. The optional part of the assignment guides to using time in network analysis.
- Refer to this link for more details: https://pro.arcgis.com/en/pro-app/help/analysis/networks/opening-the-network-dataset-properties-dialog-box.htm

Finally, after checking the parameters, you can build the network dataset using the following instructions.

- In Geoprocessing pane, search for *Build Network*.
- Select the network dataset.
- Click ‘Run’.



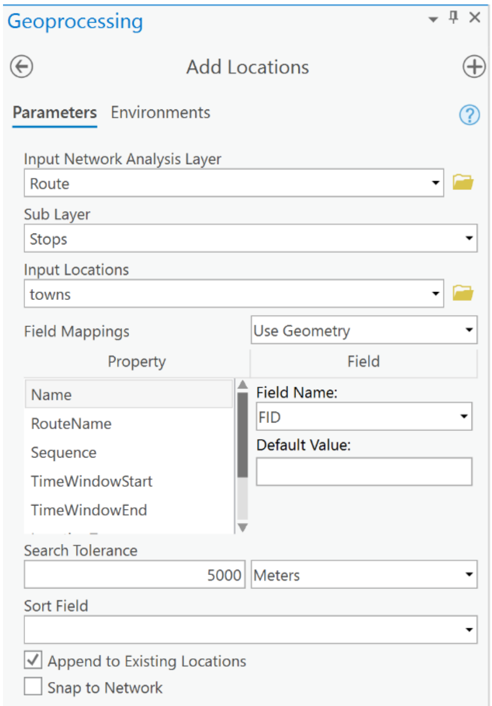
4.4 Optimal Routing

WHAT THIS FUNCTION DOES:

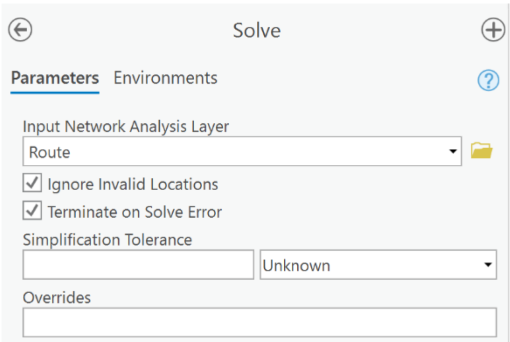
Optimal routing finds the shortest path between two *given* points, known as origin and destination (O/D). The *shortest* path is referred with regard to either network travel time or length. An extension to optimal routing is the OD matrix function that calculates the shortest travel costs, no matter time or distance, between pairs of input O/D points.

STEPS:

- Analysis ribbon > Network Analysis > Route. This procedure creates a complex layer which includes stops and routes.



- Open the towns attribute table, then select #1 (Ultima), #4 (Culgoa) and #19 (Cohuna) – these are the ones which you will find the shortest route between. Hold down the Ctrl button on your keyboard to select multiple towns. Notice that the towns are listed as numbered stops.
- Load stops: Search for *Add Locations* in Geoprocessing pane. Set the route layer as the input network analysis layer. Set sub-layer as 'Stops' and set 'towns' for input locations. Set the field name to 'FID'. Execute add locations using the Run button.
- From Geoprocessing pane, find *Solve* function.



- The cumulative distance is shown in the Total_Length column of the Routes attribute table.

Q2. Find the optimal route between stops #1 (Ultima), #4 (Culgoa) and #19 (Cohuna). Create a map visualization of the results and attach the map to your report.

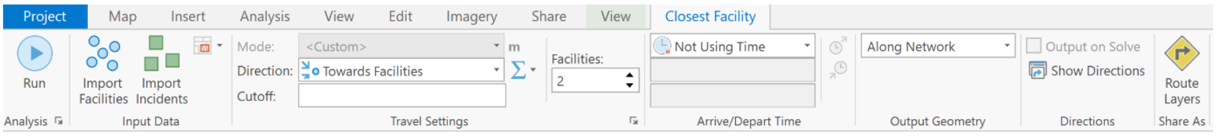
4.5 Selecting Closest Facilities

WHAT THIS FUNCTION DOES:

Closest facilities function finds the closest one or a designated number of facilities to the given origin. It requires the input of one origin and a set of potential facility locations (which functionally are identical to destinations). The analysis then calculates the travel cost between the origin and each of the facilities and return only the requested number of facilities by ascending order of the cost. Therefore, you can get a list of nearest and 2nd nearest facility, etc.

STEPS:

- Clear selected features.
- From ‘site’ layer, select Site 1 (FID = 0, Locality = Site 1).
- Analysis ribbon > Network Analysis > Closest Facility. This will create a complex layer which includes facilities, incidents, and routes.



- Now, use *Add Locations* to load Site 1 as an incident.
- Use *Add Locations* to load all towns as facilities.
- Click on Closest Facility in Contents pane. Go to Closest Facility ribbon and set the number of facilities to 2.
- Search for *Solve* in Geoprocessing pane. Set the input to Closest Facility layer and execute the function. You could also use Run in the Closest Facility ribbon.

Q3. What are the names of the two towns closest to Site1, and what are their road distances?

4.6 Calculating Service Areas

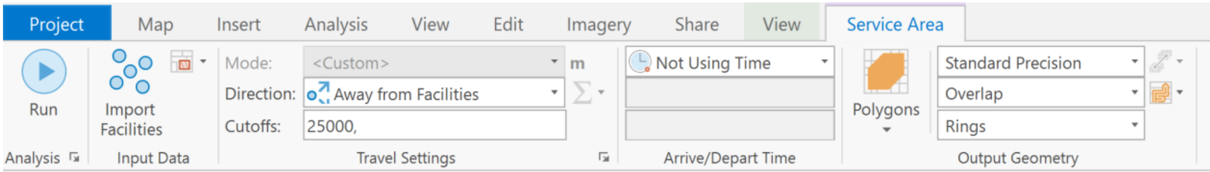
WHAT THIS FUNCTION DOES:

Service areas function also requires the input of a given origin. Besides, it also requires a given travel cost budget (in time or distance), say, 10 mins by car, or 1km. The analysis then returns all the road segments that are within the travel budget from the given origin. The mechanism is to calculate the travel cost from the origin to each vertex on each road segment of the road network until it hits the travel budget, for which this analysis is computationally expensive.

STEPS:

- Clear selected features.
- Select Swan Hill from ‘towns’ (i.e. site#0 of towns.shp).
- Analysis ribbon > Network Analysis > Service Area. This will create a complex layer which includes facilities, and polygons.
- Click on Service Area layer in Contents pane. This will activate the Service Area ribbon.
- Service Area ribbon > Import Facilities. Set load input to ‘towns’. Click ‘Run’ to add locations.

- Service Area ribbon > set Cutoffs to 25000 m (25km). Click Run to execute service area analysis.



Q4. Describe the result of your service area network problem. Include a screen grab (i.e. "print screen" button, paste it, and crop it).

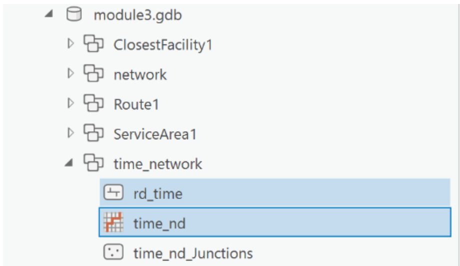
Q5. Without calculating the service areas, would the service area within 25 km of the township of Chinkapook be larger than that of Barham? Justify your answer.

4.7 A few more exercises if you like (optional)

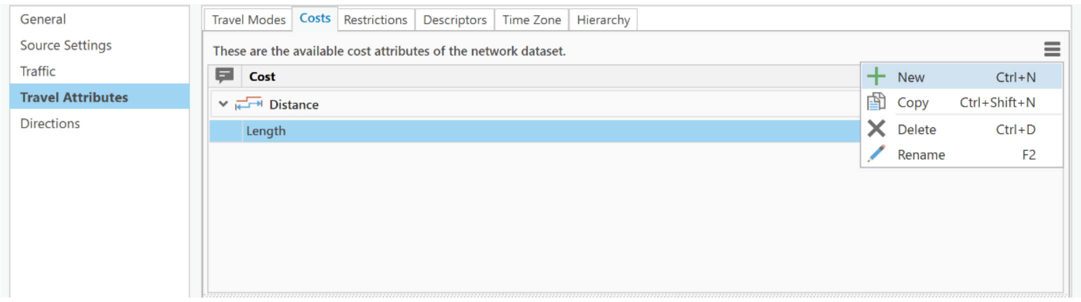
So far, we have used distance as the cost factor in our network analysis computations, but a more effective cost unit is travel time. As such, various speeds have been assigned to the different roads types: that is, regional roads (100 km/h), main roads (80 km/h), local roads and streets (60 km/h), farm roads (15 km/h) and tracks (10 km/h). Then the travel time for each road segment was computed by dividing each road segment by 1000 (to give the distance in km), dividing the km distance by the allowable speed for that segment and multiplying the result by 60 to give the travel time in minutes. This value is given in the *travel time* column in the roads database.

Now let's solve some very real problem faced when allocating services. We need to specify the time as the cost function for network dataset.

- First, create a new network dataset. After creating the network dataset, remove it from Contents pane (right-click > remove).
- Go to Catalog pane and find the network dataset inside the geodatabase.



- Right-click on the network dataset and go to properties.
-
- Travel attributes > Costs > New.
- Add time as the cost function. Delete length from the list.

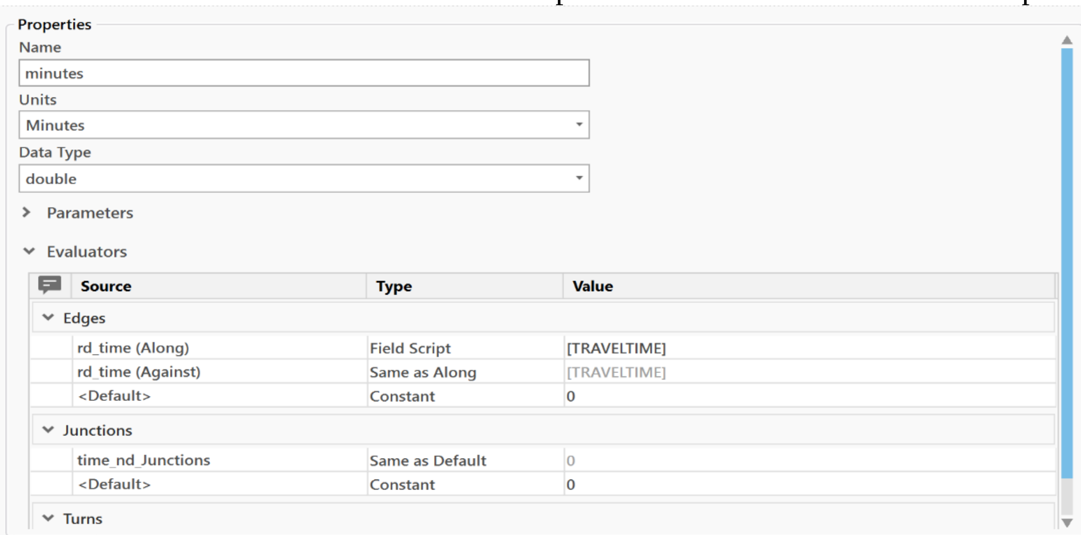


https://pro.arcgis.com/en/pro-app/help/analysis/networks/cost-attributes.htm

- Add the network dataset to Contents pane. Run *Build Network* to build the network dataset using time as the cost function.

Note: Make sure to choose the correct network dataset when you apply a network analysis method. You could change the network datasets in Analysis ribbon > Network Analysis > Change network data source.

Task 1: Find the optimal route (in terms of travel time) between Site1 and Site2. Make travel time the cost field in terms of minutes in the Properties box. Then solve the network problem.



Q6. What is the shortest travel time between Site1 and Site2? Zoom in to the Site1-Site2 area and make a map of the selected route.

Task 2: Find the nearest facility (e.g., a fictitious doctor's surgery in any of the nearby towns) to Site2. For the purposes of this exercise, you should treat the towns as facilities. Make travel time the cost field in the Properties box. Make the cut-off cost 60 minutes and solve the problem.

Q7. What are the two closest facilities (towns) to Site2 and what are the travel times to each of them? Do these shortest travel time routes differ from the shortest distance routes? Justify. Make a map of the selected route to the three nearest towns.

Task 3: Find the service areas of the secondary schools in the towns called Swan Hill (#0) and Kerang (#18) surrounding Site1. This is defined as 31 minutes of travel time by road. Make travel time the cost field in the properties box then delete all unwanted sites in the label column. Give each of these two school sites 31 minutes travel time in the minutes' column and highlight the two sites in the box. Solve the network problem and observe the results.

Q8. What secondary school service area does Site1 lie in? Make a map of the service areas of the secondary schools at Swan Hill and Kerang.

Appendix: A Run Through of Additional Skills

1. CREATING A GEODATABASE

To manage your own spatial database, you can create a file geodatabase. If you do this, your data will be stored in a Microsoft Access database.

- Open Catalog pane. Connect to your working directory by clicking on the Connect to

Folder (right-click on Folders in Catalog pane). This creates a link to your working directory which shortens the access to your folder for future use.

- Right-click on your working directory then select New > File Geodatabase to create a new database that will handle all the data for your project.

2. CREATING A FEATURE DATASET

A Geodatabase can contain different Feature Datasets, each dataset represents the data for one project. For example, if you create a Geodatabase for Australia, then inside this database you can create Feature Datasets for Melbourne, Sydney, and each dataset contains the data for a specific state.

Right-click on the Geodatabase you just created and click New > Feature Dataset. First, define a name for the dataset and click next, then click the Import button to set the coordinate system for this feature class from an existing feature class. See Fig. 1.

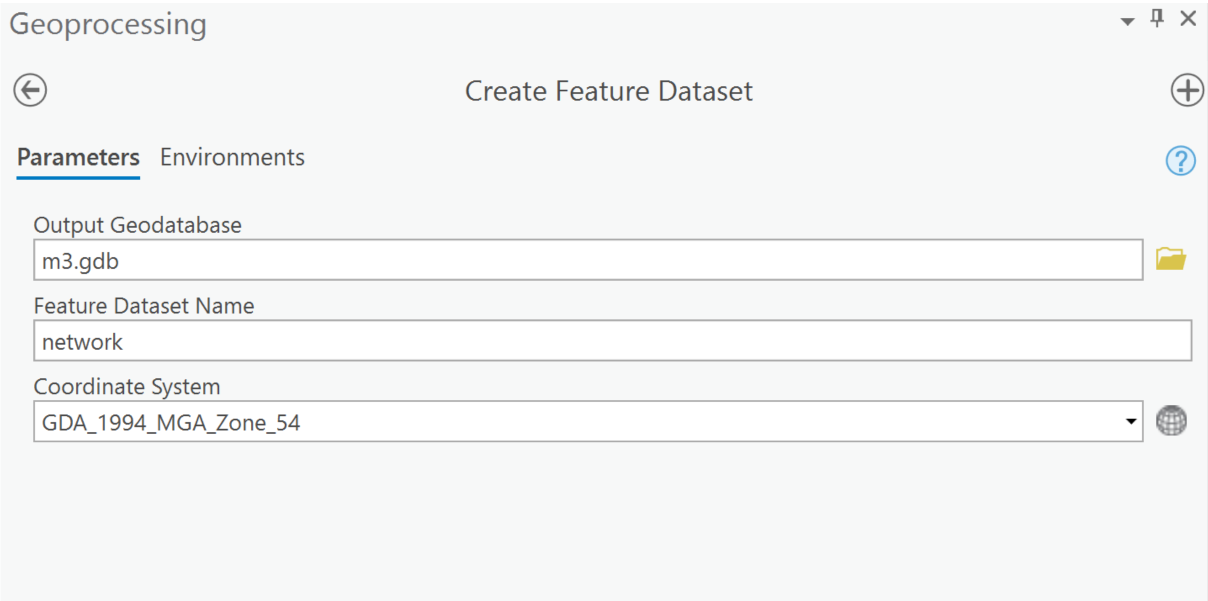


Figure 1: New Feature Dataset.

3. CREATING A FEATURE CLASS

Right-click on the Feature Dataset you just created and click New>Feature Class, the New Feature Class dialogue box will appear then write the name for the new feature class. In Type Field you can select Point, Line, Polygon or others, then click next, see Fig. 2.

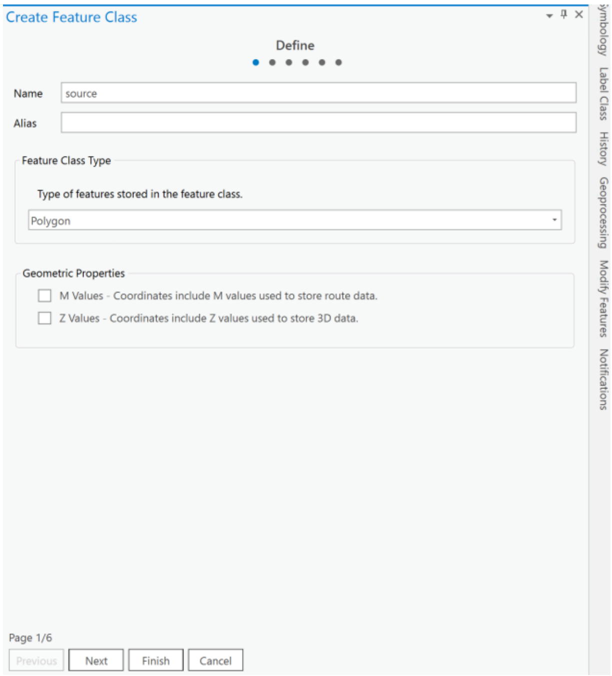


Figure 2: Name of a new feature class.

Finally, click Finish to create the new feature class. See Fig. 3.

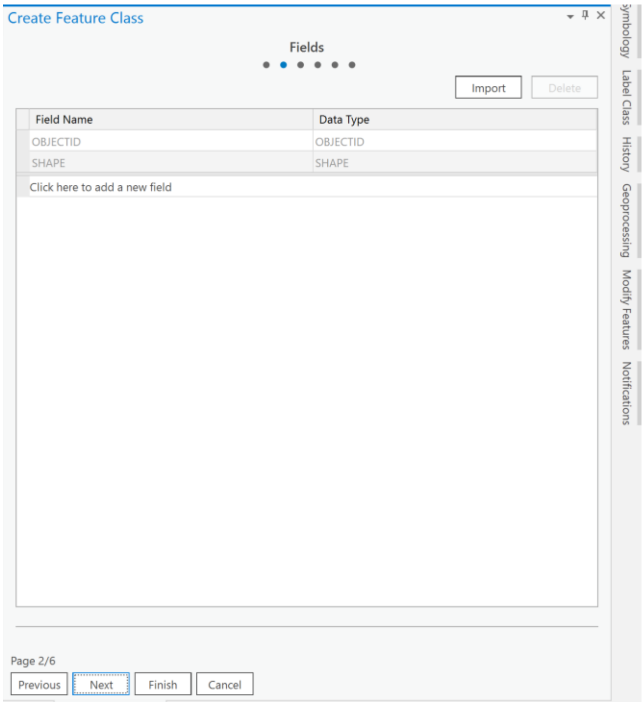


Figure 3: Properties of a new feature class.

4. DELIVERABLE

Submit a document with just the answers to the questions.

5. ASSESSMENT

The mini-module is worth 2 marks. To receive 1 mark (a “pass”) the answers have to be complete. To receive 2 marks the answers have to be complete and correct. There are no fractions.