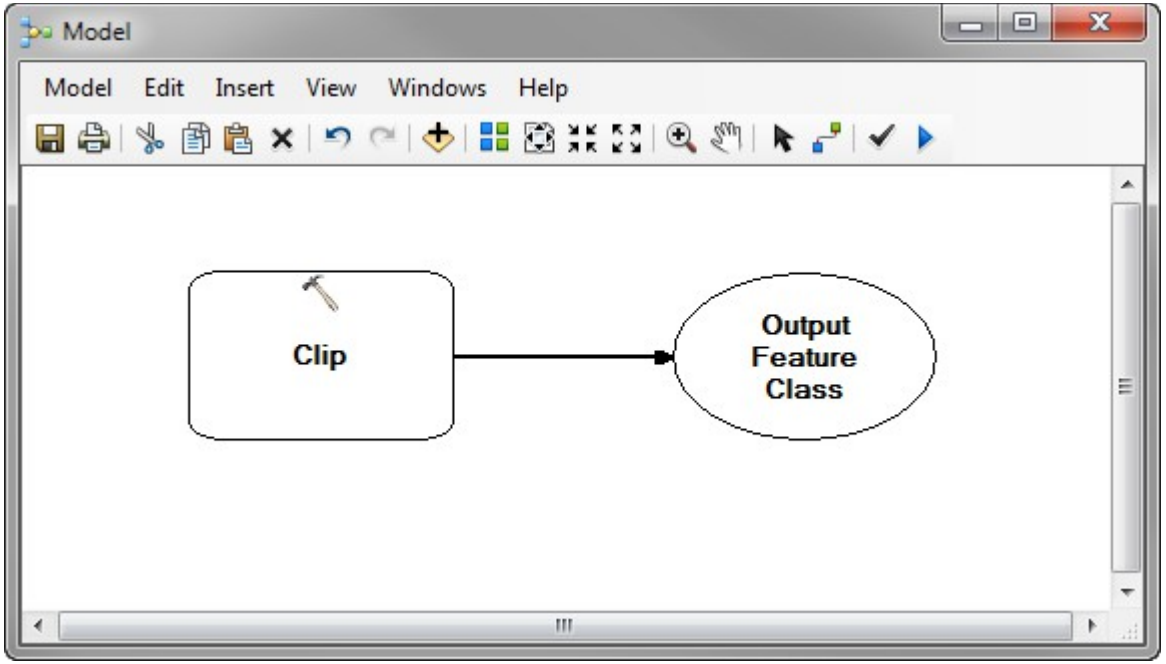
Introduction to Model Builder and Python v5



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Topics Covered

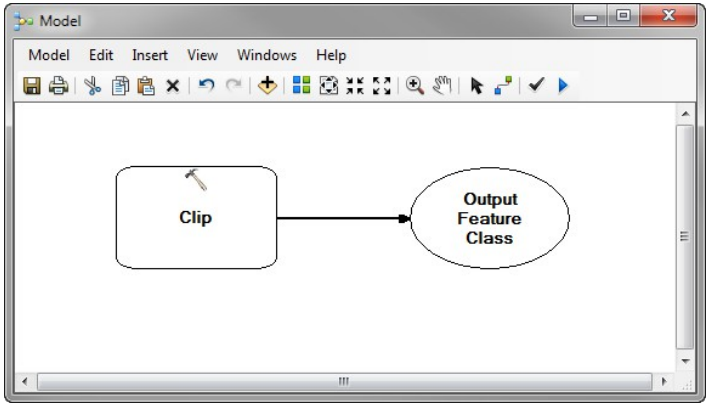
- ArcToolbox
- Geoprocessing
- Models
- Iterators
- Model Only Tools
- Exporting to Python and ArcPy
- Modeling and Scripting with Python

Why Build Models

- Automate repeated processes
- Flowchart Analysis Process
- Provide documentation for process
- Provide tools others can use to perform analysis
- Standardize workflows

Introduction to Model Builder

Chapter 1: ArcToolbox Basics



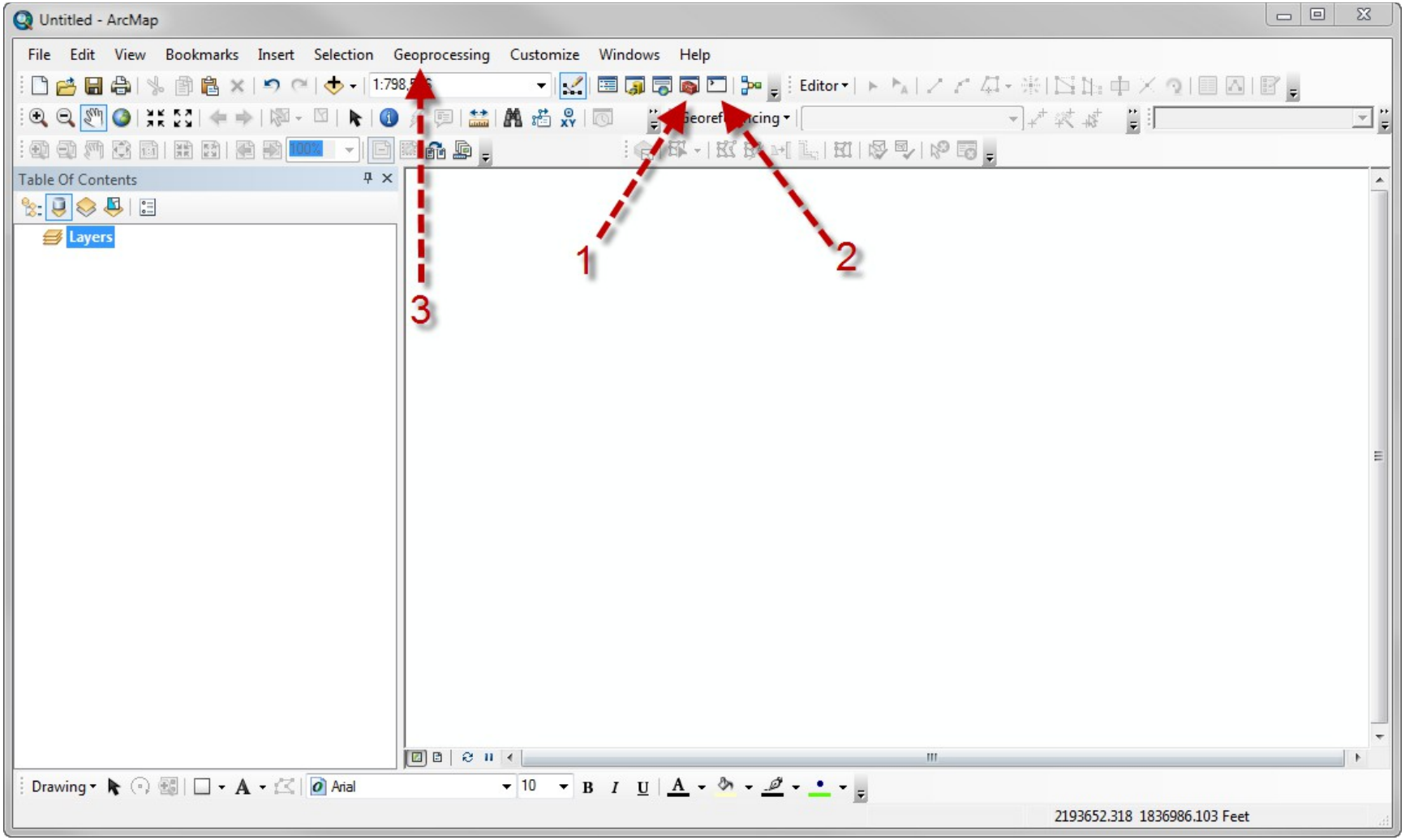
python

Intro To ArcGIS

- **ArcINFO** – released in 1982
  - Version 4.0 introduced AML
  - Arc Macro Language
- **ArcView GIS**– released in 1995
  - Arcview 3.0 introduced Geoprocessing Wizard
  - Also introduced Model Builder w/Spatial Analyst
  - Avenue
- **ArcGIS** – 1999
  - Model Builder
  - Python appears in 9.1

Python

- **Open Source**
- **Used everywhere:**
  - Microsoft, Google, NASA, Open Source GIS software, etc.
- **Developed in the late '80s by Guido Van Rossum**
  - Benevolent Dictator for life
  - Worked for Google
  - January 2013 began working for DropBox
- **ArcGIS 10.1 ships with 2.7**
  - 3.x is the current release



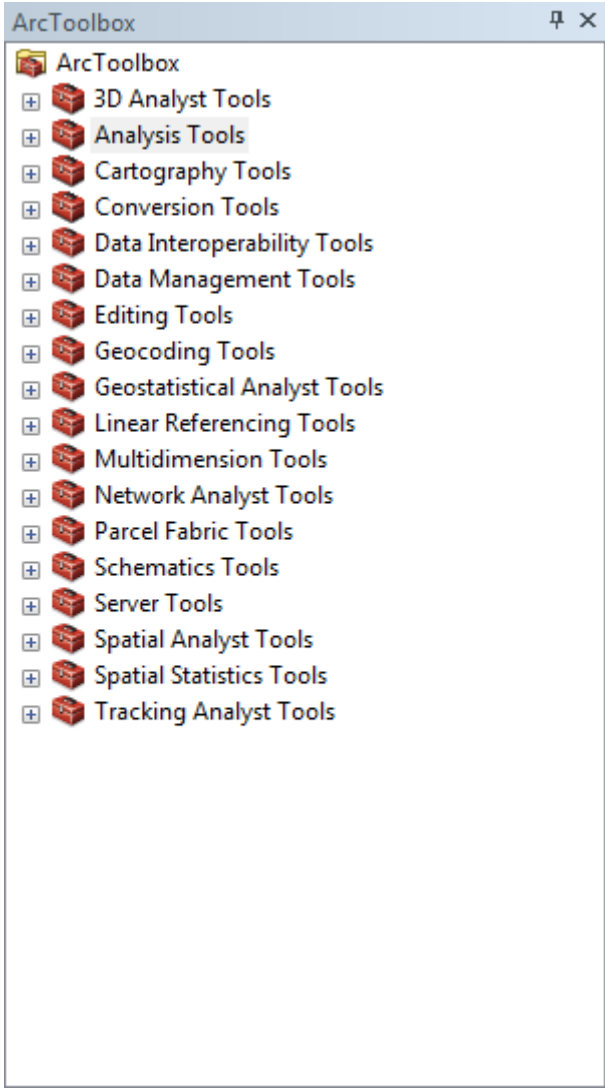
1. ArcToolbox 2. ModelBuilder 3.Geoprocessing

ArcToolbox

- The fundamental purpose of geoprocessing is to provide tools and a framework for performing analysis and managing your geographic data.
- Geoprocessing tools are tools ranging from simple to complex that let you work with your data
  - Add a field
  - Buffer a feature
  - Clip data

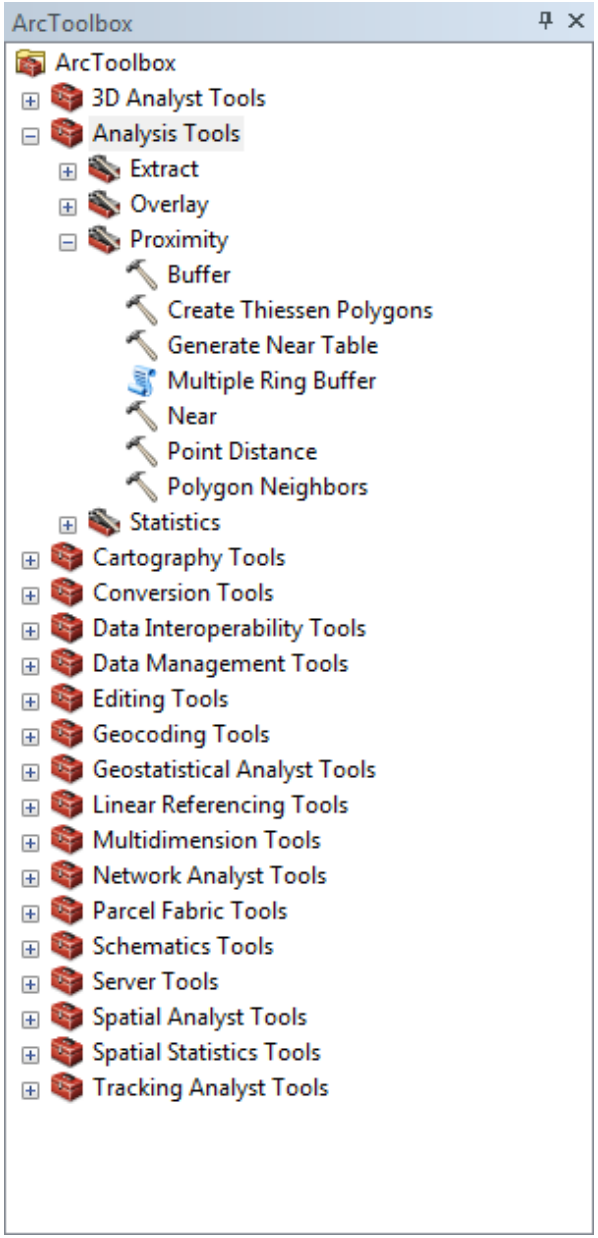
ArcToolbox

- ArcToolbox is made up of tools, scripts, and models.
- Can be executed one at a time or several at once.



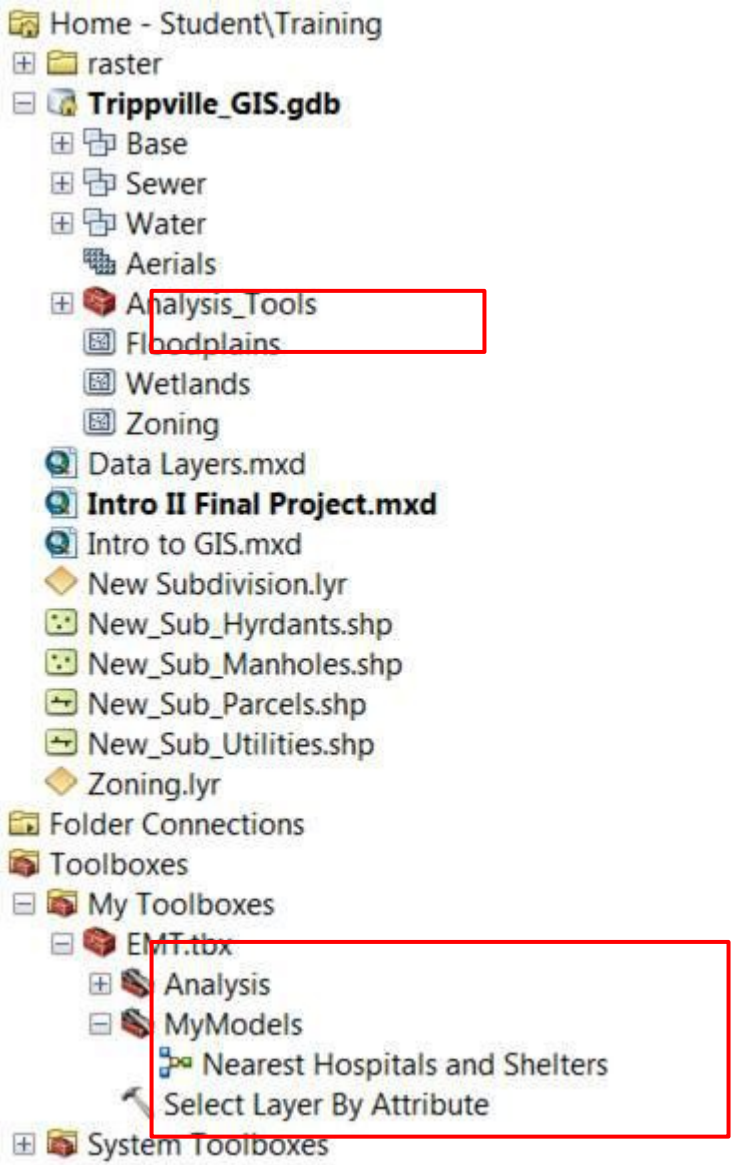
Tools and Scripts

- Every Tool has a Python "Interface"
- Tools can live within Toolsets. Toolsets are a "directory" of tools
- Scripts and Tools can be combined in Models in ArcToolbox



Toolboxes Can Be Built Anywhere

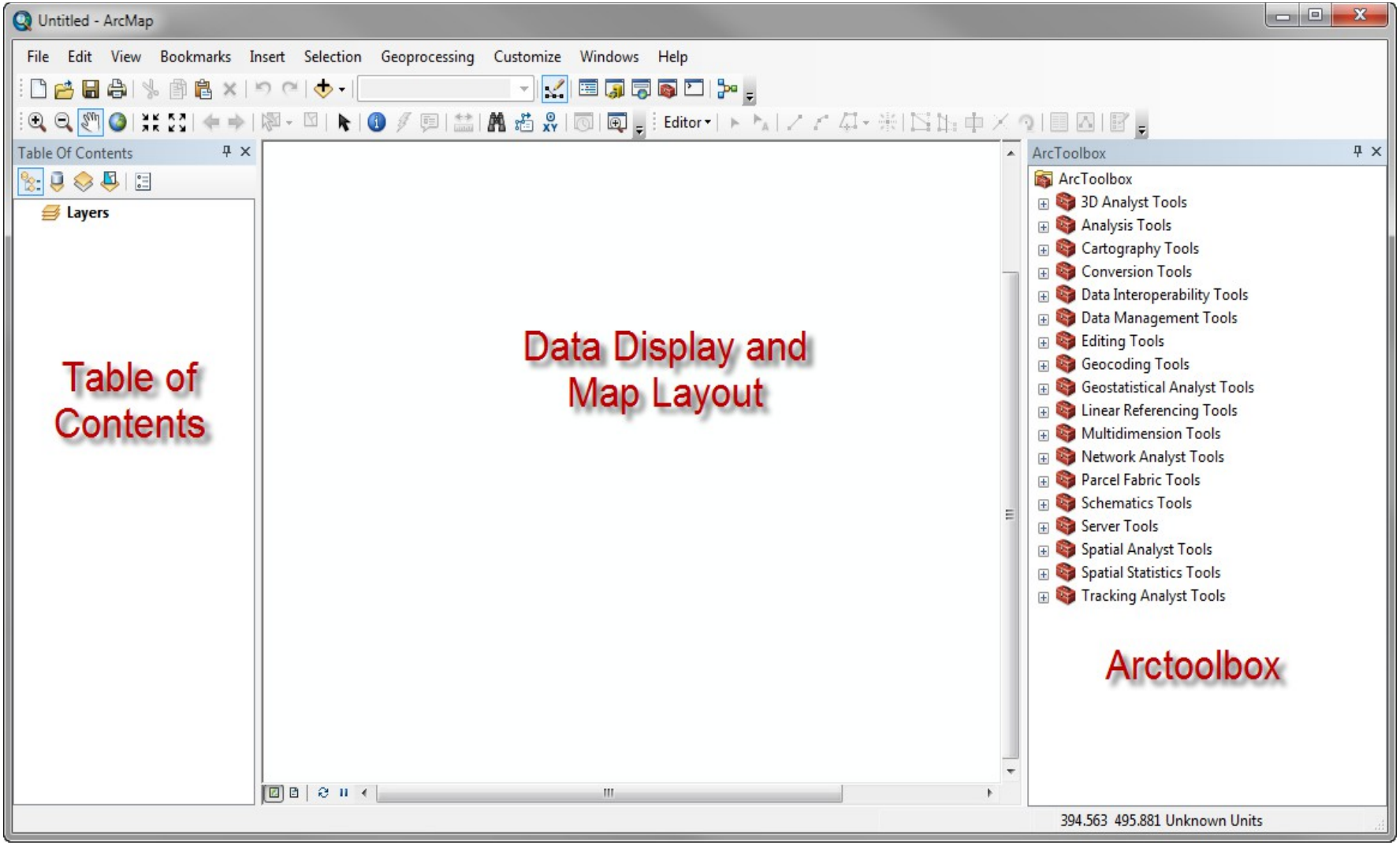
- Stored in:
  - Directories
  - Geodatabases
- Can be shared
- Can be stored on ArcGIS Server



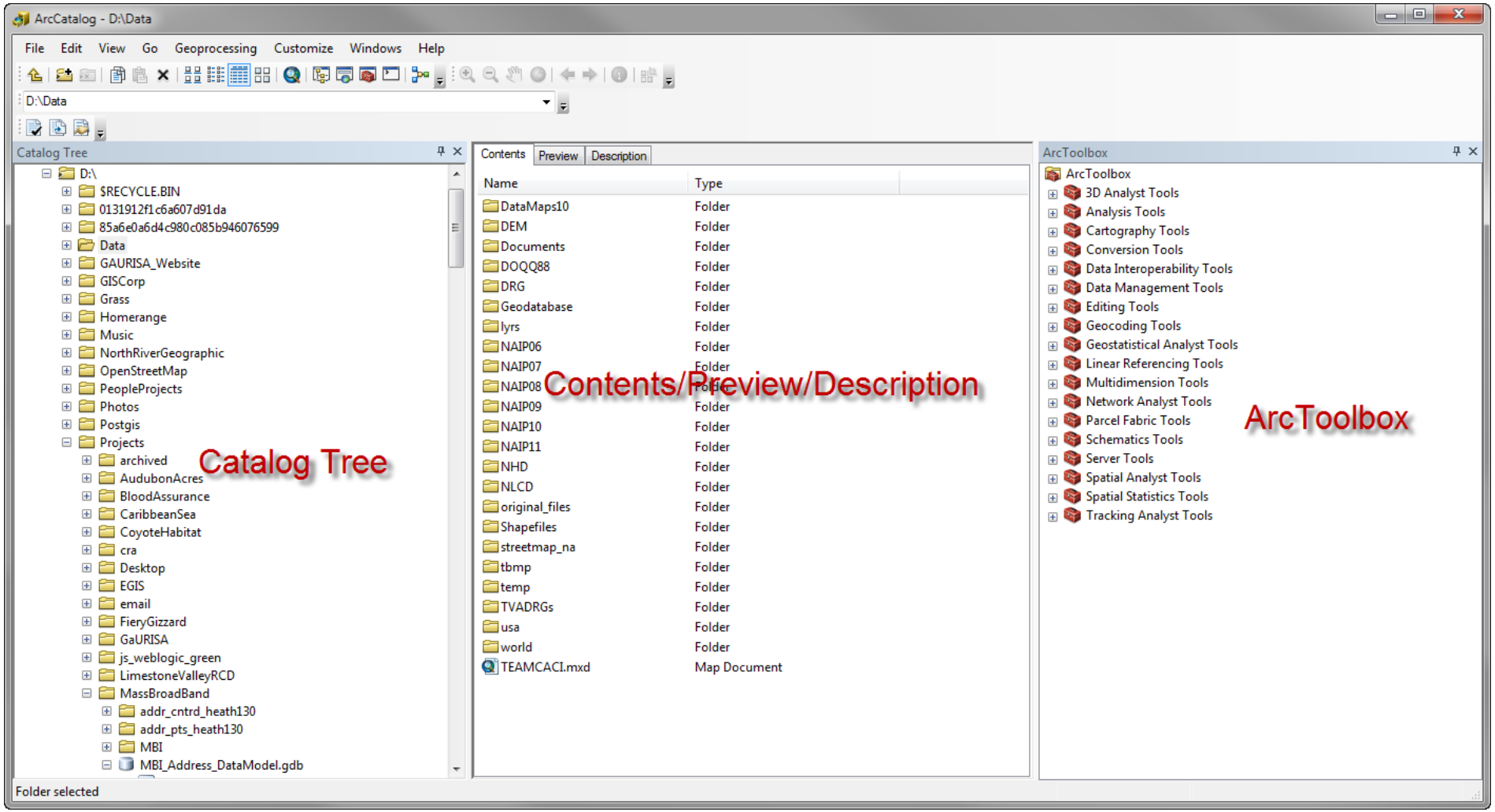
ArcToolbox

- Built into ArcCatalog and ArcMap
- ArcMap and ArcCatalog have an ArcToolbox window.
- Tools/Toolsets/Scripts can be deleted from an ArcMap MXD.
- Deleted tools can be restored from the System Toolbox located in ArcGIS Install folder.
- Can save customizations to and load from an XML

ArcToolbox in ArcMap



ArcToolbox in ArcCatalog



Exercise 1

Explore ArcToolbox

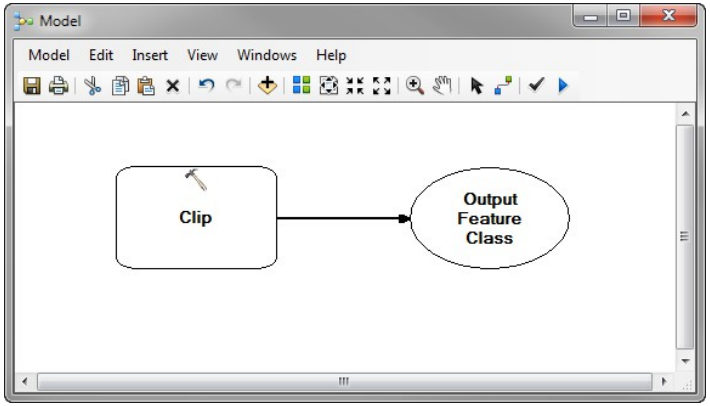
Get to know ArcToolbox organization

Examine different ways to access geoprocessing tools

15 to 20 minutes

Introduction to Model Builder and Python

Chapter 2: Geoprocessing Basics

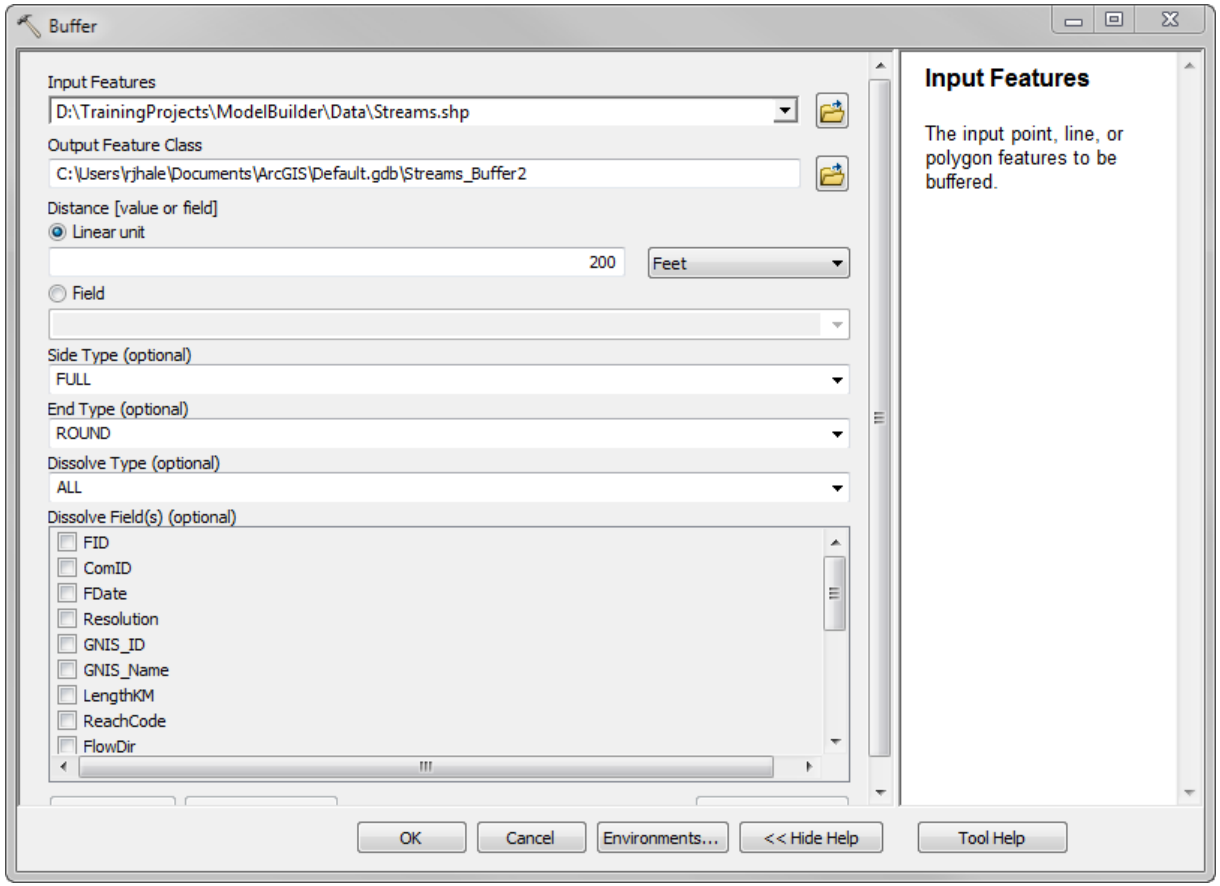


2. Geoprocessing Tools

- ArcToolbox holds Geoprocessing tools
- Tools take an input (raster/vector/table) and a output (raster/vector/table) and several parameters to run
- These tools typically do three things usually to data
  - Modify Data
  - Create/Delete Data
  - Reports/Statistics on Data

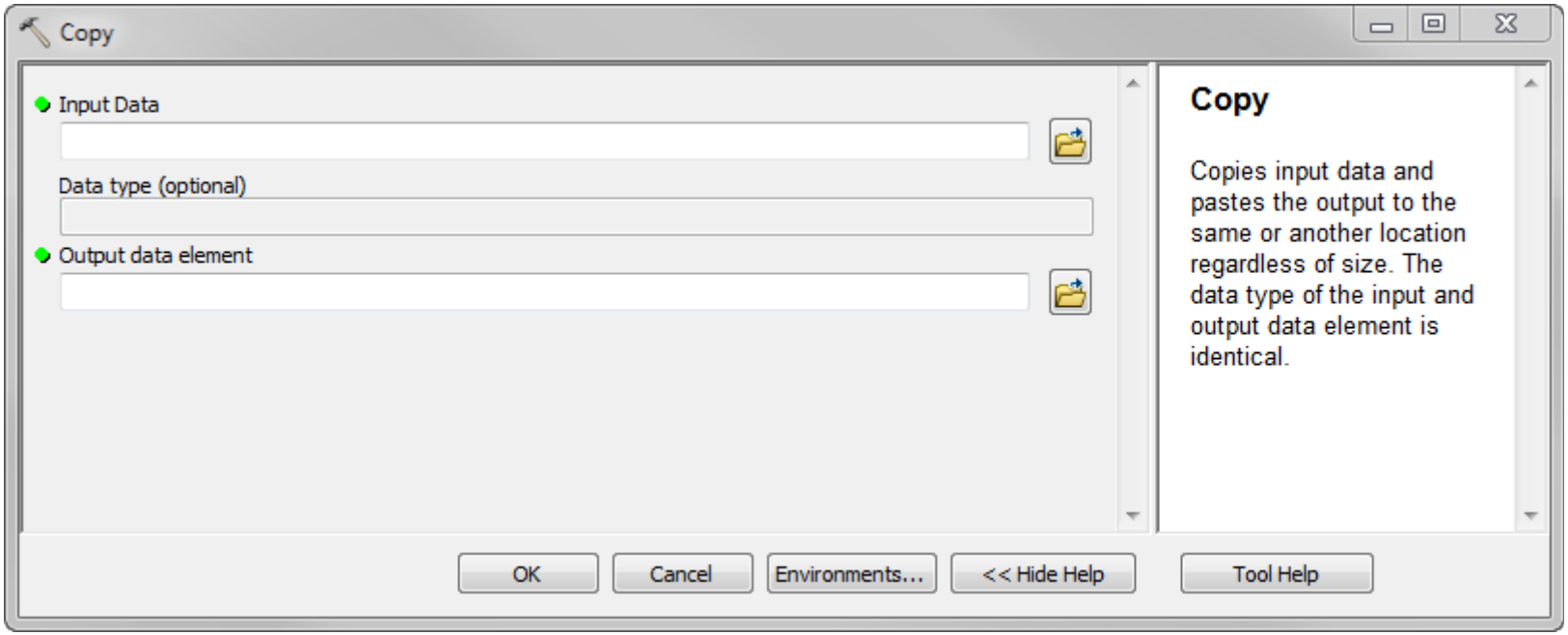
Geoprocessing Tool

- Example of a tool: Buffer



Geoprocessing Tool

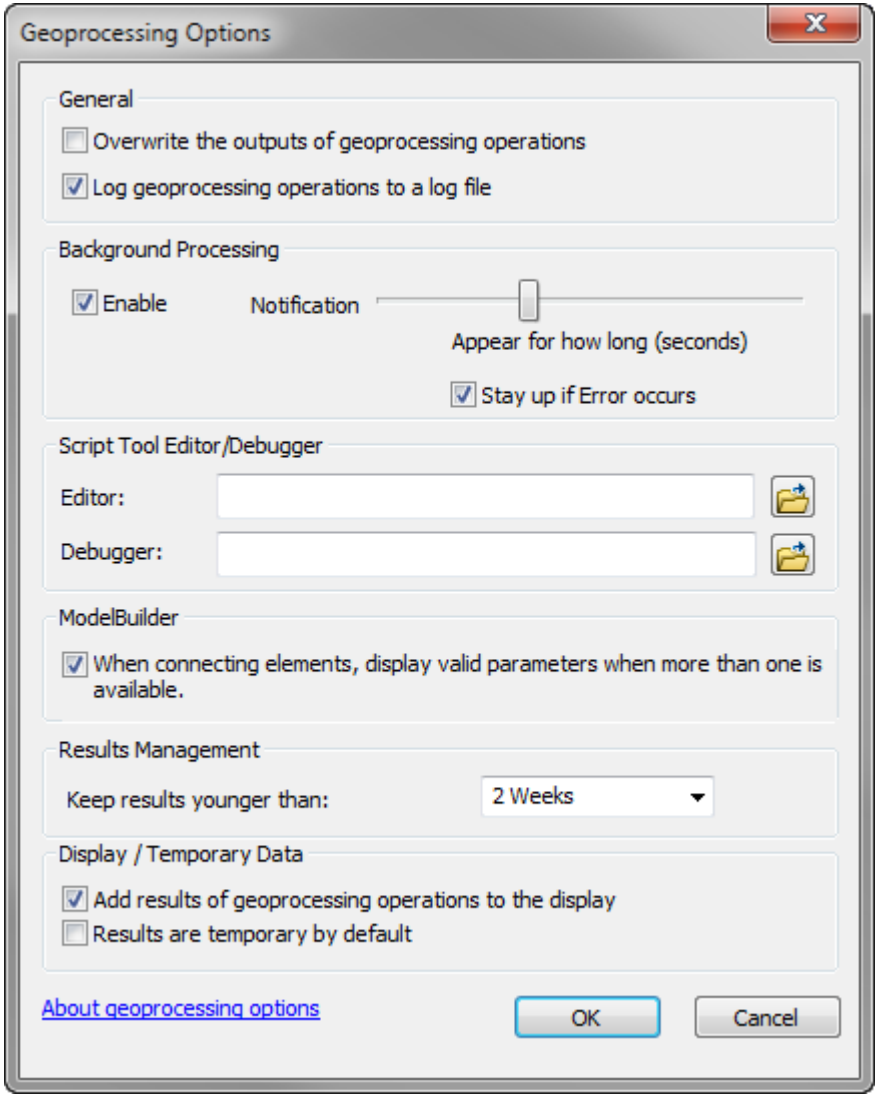
- Example of a Tool: Copy Data



Geoprocessing Options

- Found under the Geoprocessing Menu in ArcMap and ArcCatalog
- Controls how Geoprocessing runs.....
  - Background Processing
  - Foreground Processing
  - Results (Temporary or Permanent)
  - How long results are kept per MXD

Geoprocessing Options



Processing

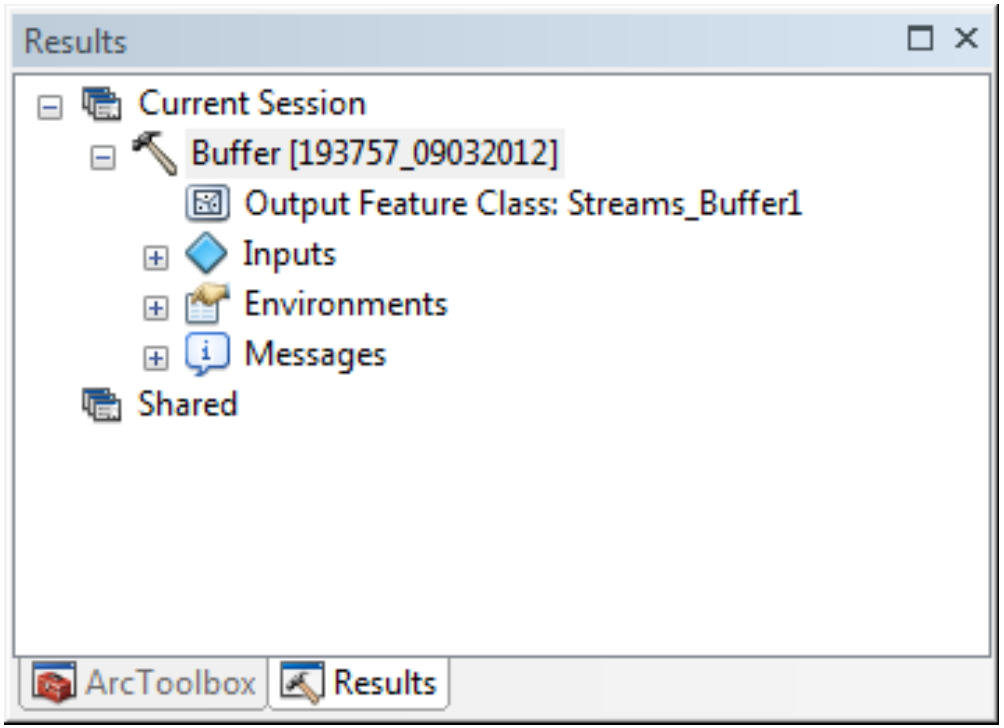
- Foreground
  - Focus is on Processing
  - One Process is run at a time
  - Wait for the one process to finish
- Background
  - Process is "forked off" and runs by itself
  - Supports multiple processes being run at once
  - More Flexible

Results Window

- When you run a Geoprocessing tool your data is saved in the results window
  - Data location
  - Time run
  - Variables
  - Saved in MXD
  - Shared as a Geoprocessing Package (GPK) or Service
  - It is kept by default is two weeks

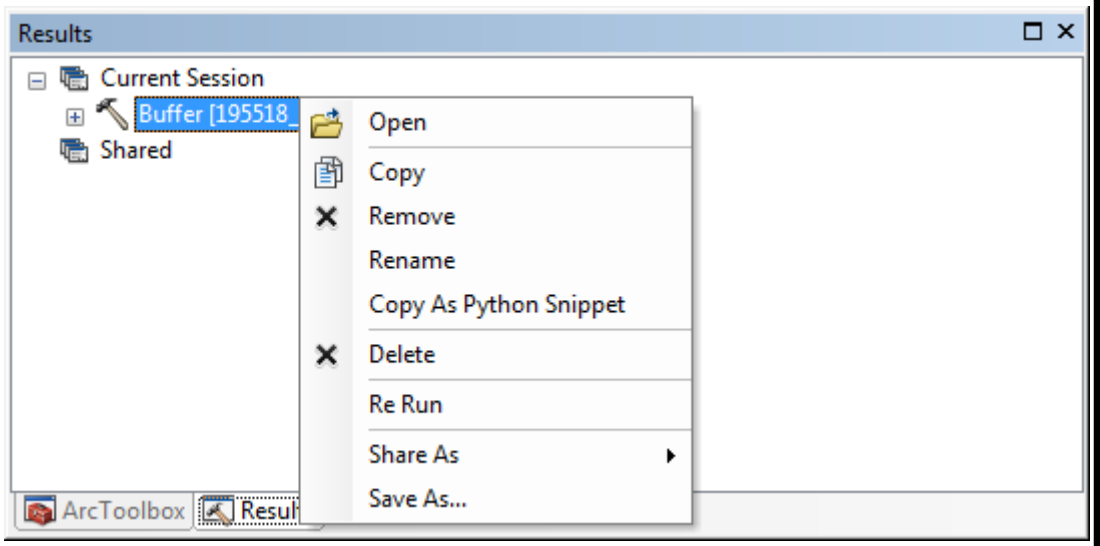
Results Window

- Found under Geoprocessing Menu
- Tools can be rerun from here without filling out all the information again
- Check messages if something happened



Results Window

- Notice your options when the result is right-clicked



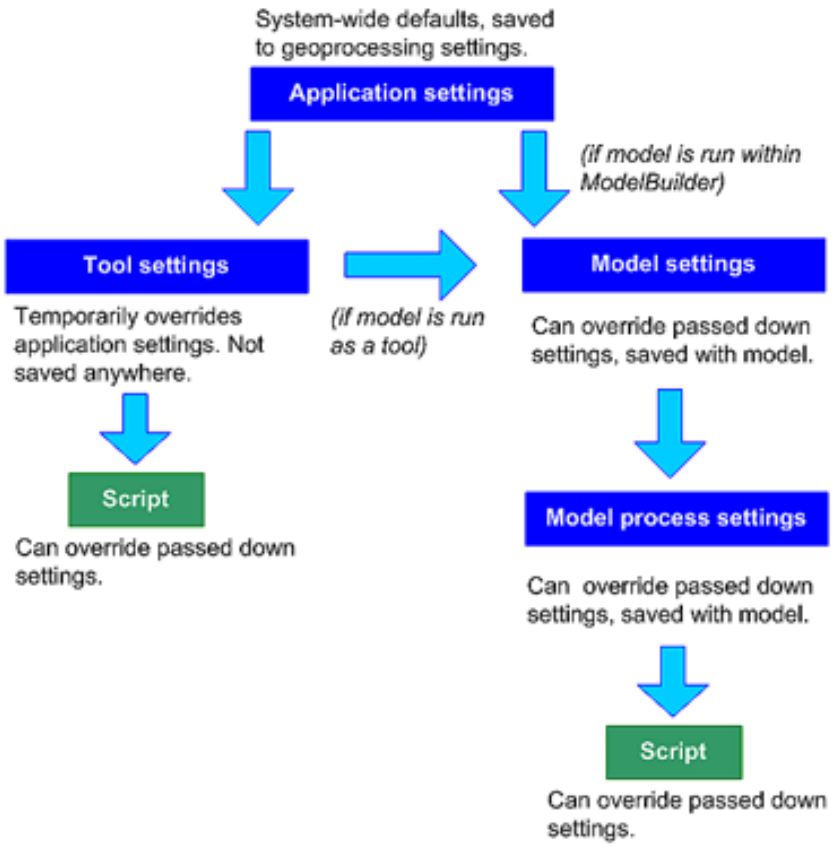
Environmental Variables

These are parameters that are entered to allow the tool to run.

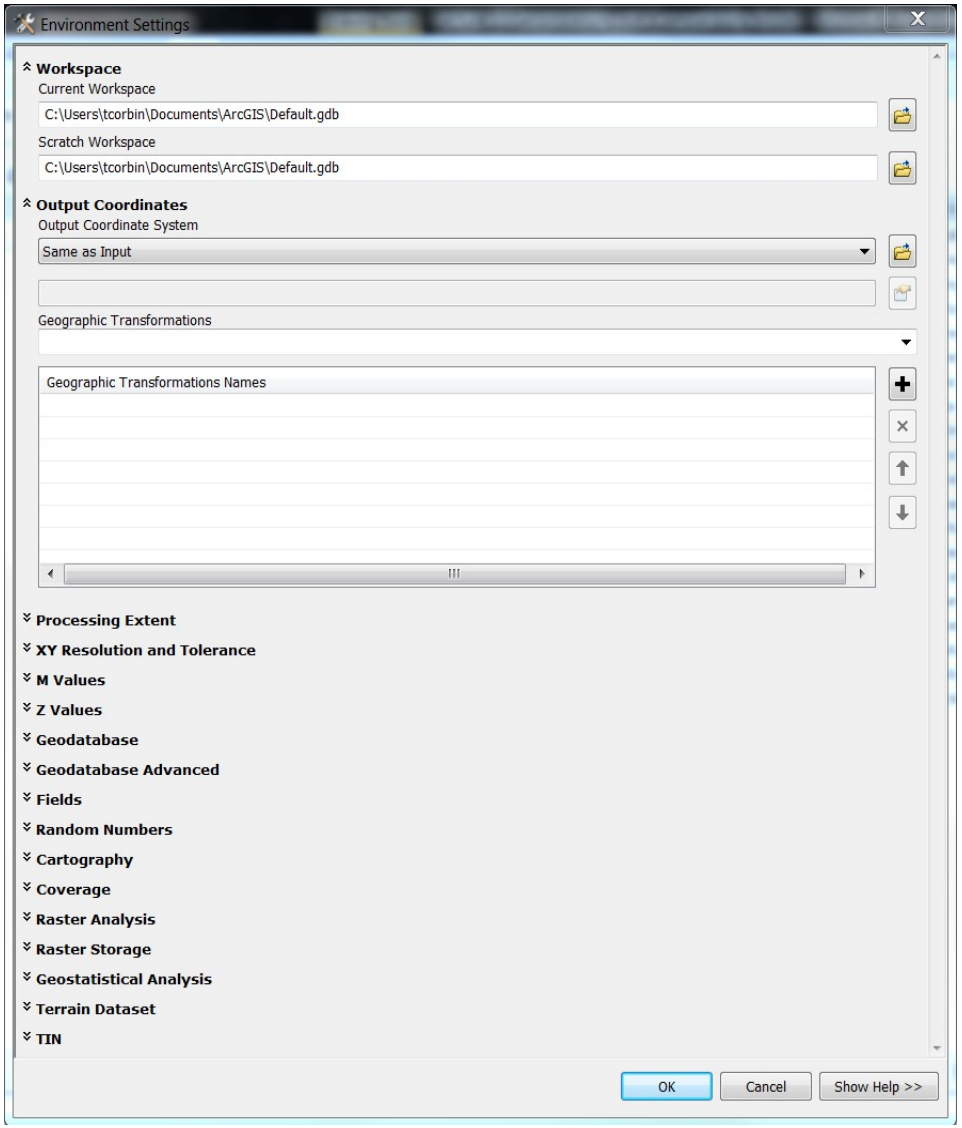
- File names
- Buffer widths

Four Levels

- Application
- Tool
- Model
- Model process



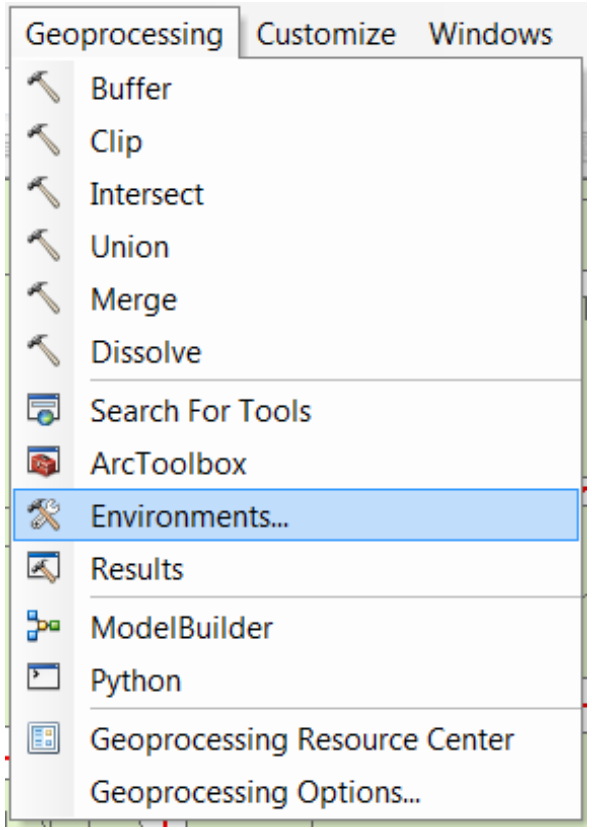
Environments

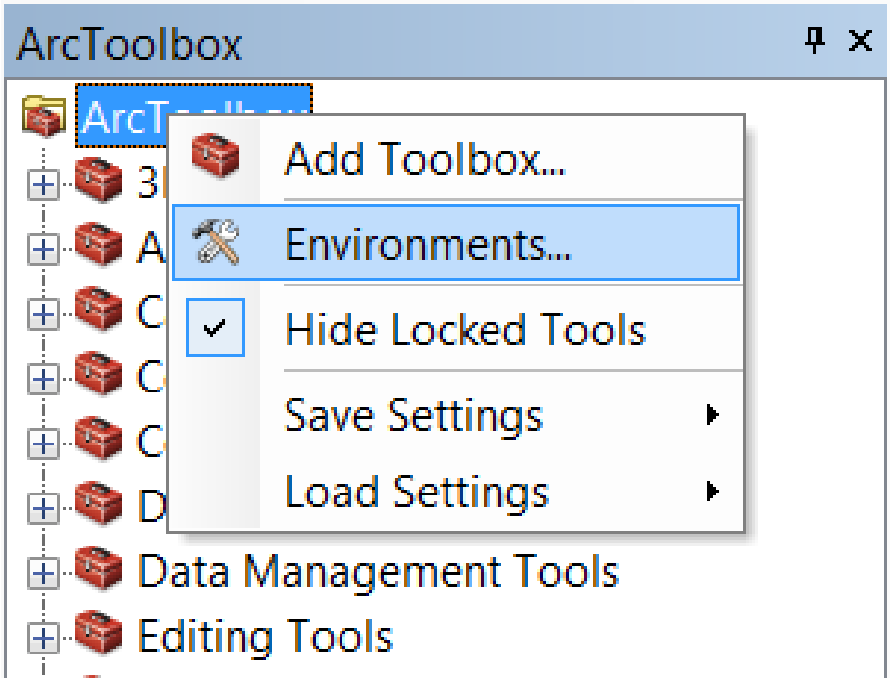


- Workspace
- Output Coordinates
- Processing extent
- XY Resolution & Tolerance
- M Values
- Z Values
- Geodatabase
- More…

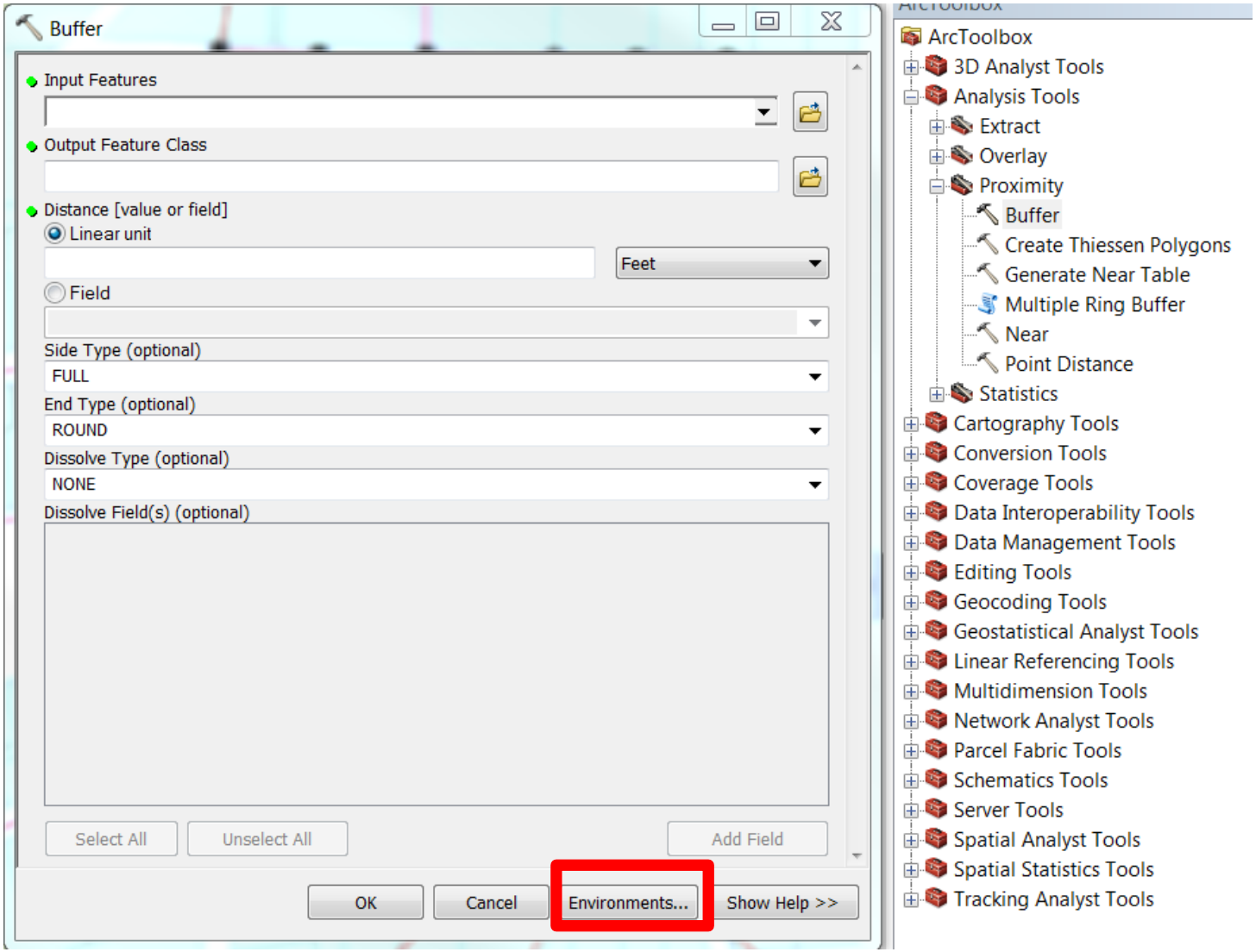
Application Level

Set through Geoprocessing menu or ArcToolbox

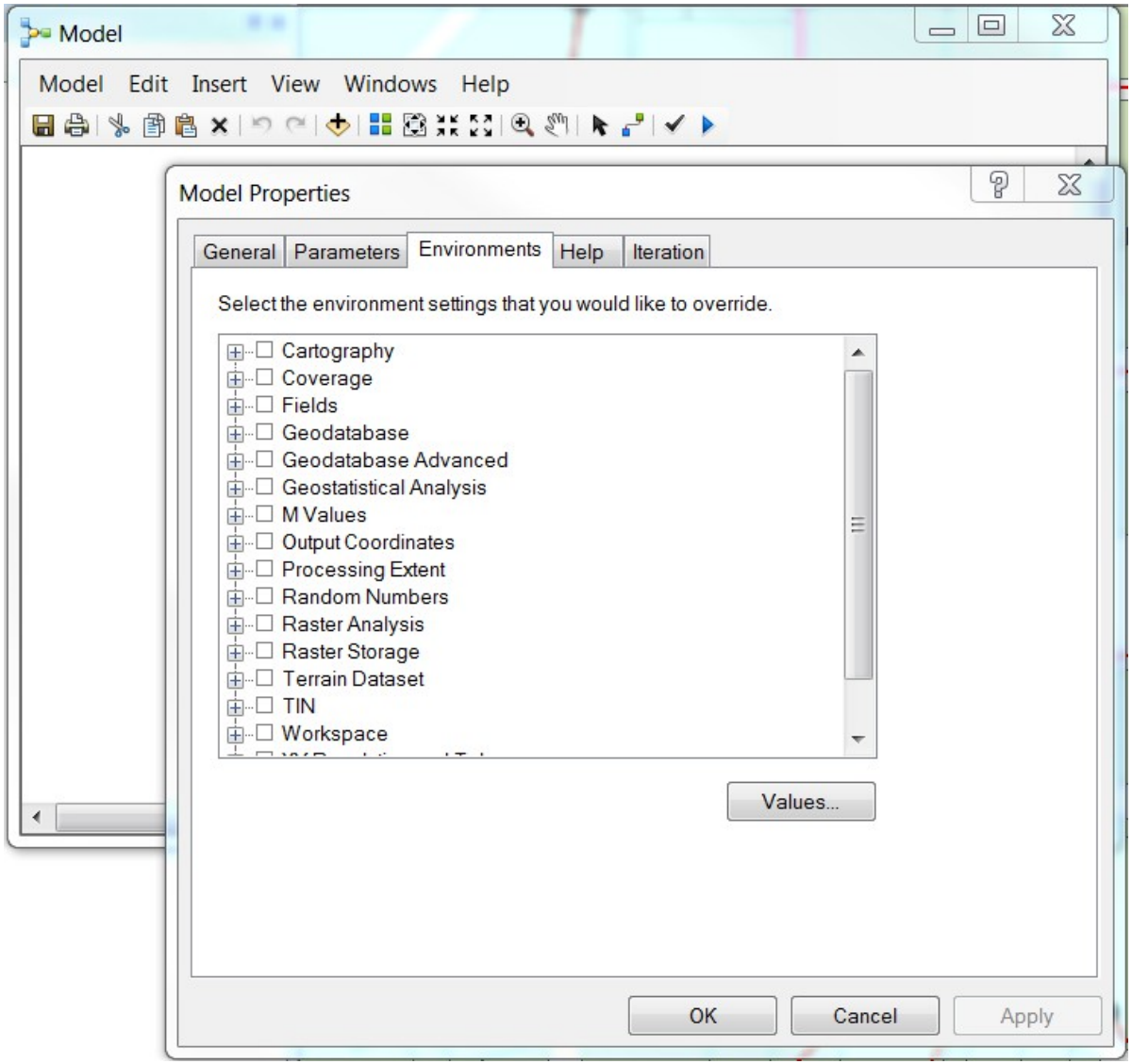




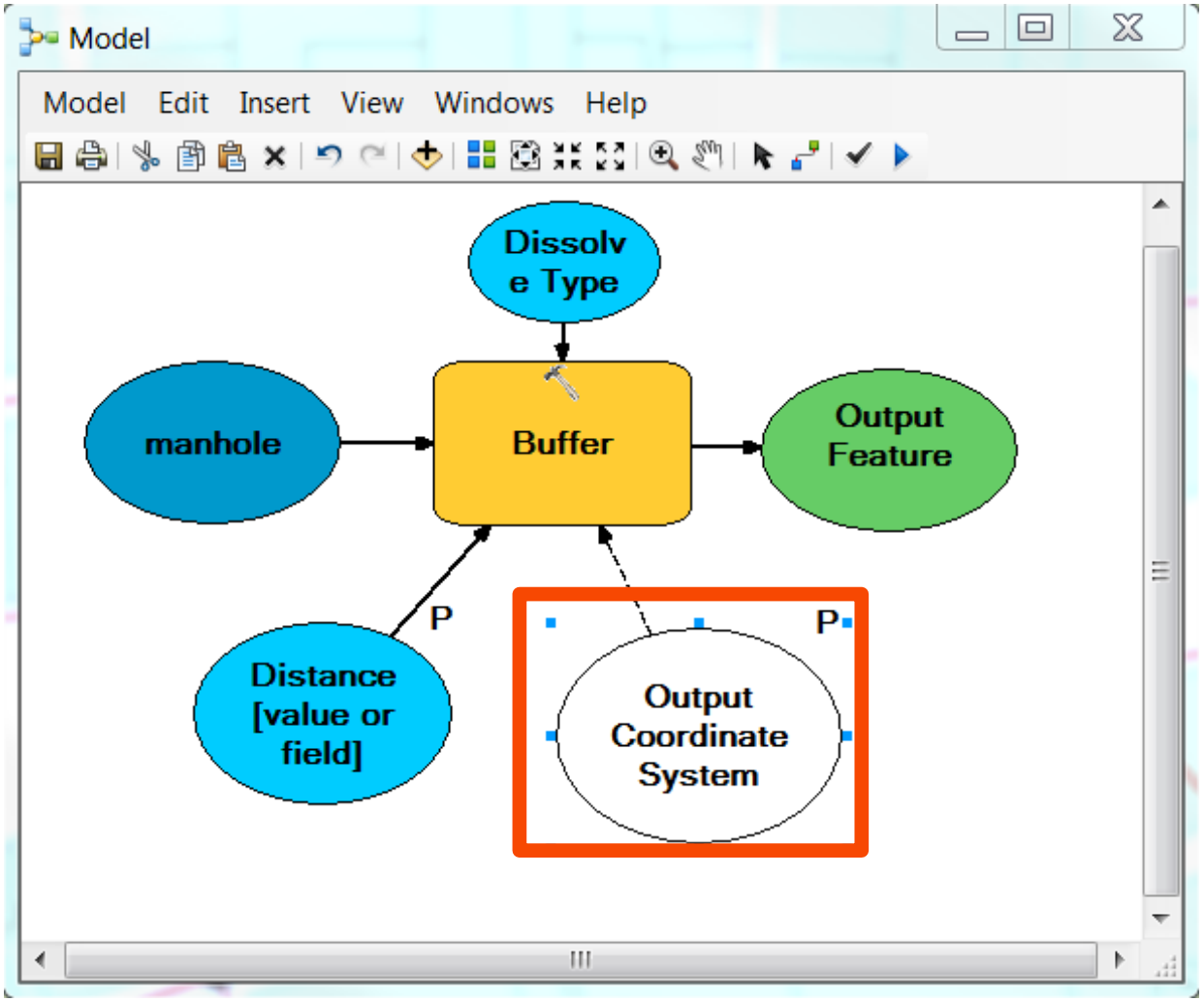
Tool Level



Model Level



Model Process Level



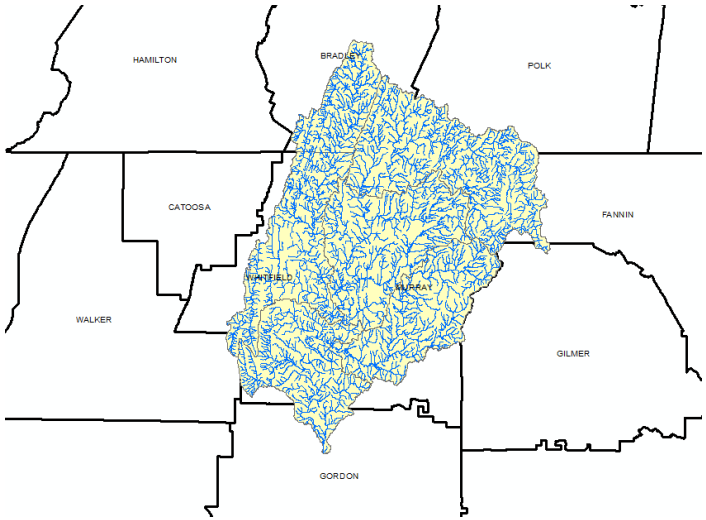
Exercise - Chapter 2

- Open ArcToolbox
- Create a Toolbox
- Look at the Geoprocessing Options box
- Change if tools run foreground or background
- Look at the Results Window
- 15 to 20 minutes

Exercise

The data for this project comes from a Project with the **Conasauga River Alliance**.

This data was collected from Aerial photography and the National Hydro Dataset.



1. You should have a **C:\modelbuilder** directory. If not please create one. Under that you should be a data directory. Add all the shapefiles to your display and symbolize appropriately.

2. Create a **Toolbox** directory, a **MXD** directory, and an **output** directory

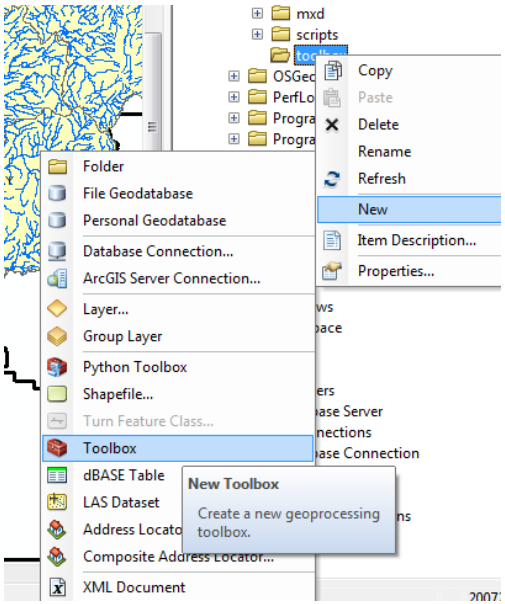
3. Save this map document under the c:\modelbuilder directory as Exercise2.mxd.

4. Double check and make sure you have the following directories: mxd, output, and toolbox

5. Open **ArcCatalog** (Either in Arcmap or as a standalone application).

Exercise

6. In ArcCatalog **Create a Toolbox** by right-clicking in the toolbox directory, selecting **New** and then **Toolbox**. Give it a name.



7. Close ArcCatalog

8. Open ArcToolbox. Explore the tools and scripts that are contained under the toolbox application.

Exercise

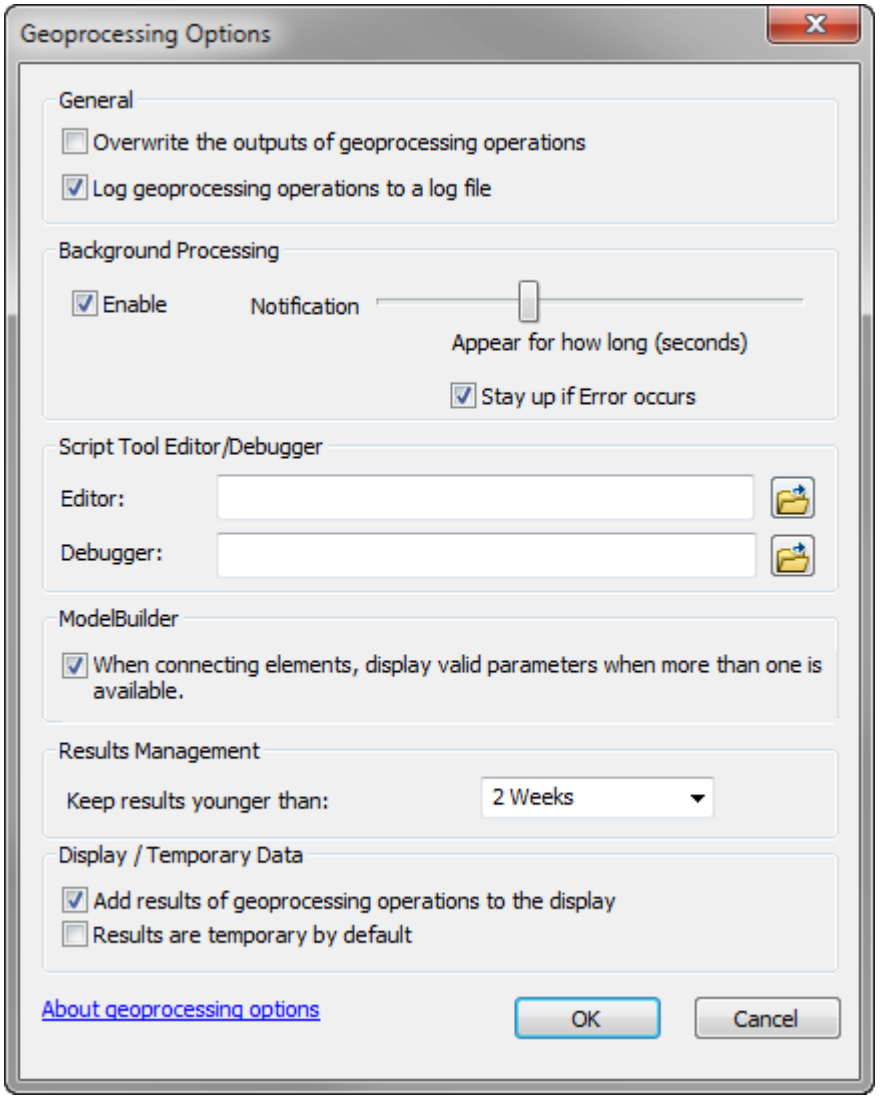
9. Open the **Geoprocessing Options** menu under
the **Geoprocessing menu** at the top of ArcMap.

10. Check **Overwrite the outputs of geoprocessing**
operations.

11. Turn off **Background processing**

12. Change Keep your **Results** to "never delete".

13. Click **OK**.



Exercise

14. Open the **Buffer** tool in ArcToolbox.

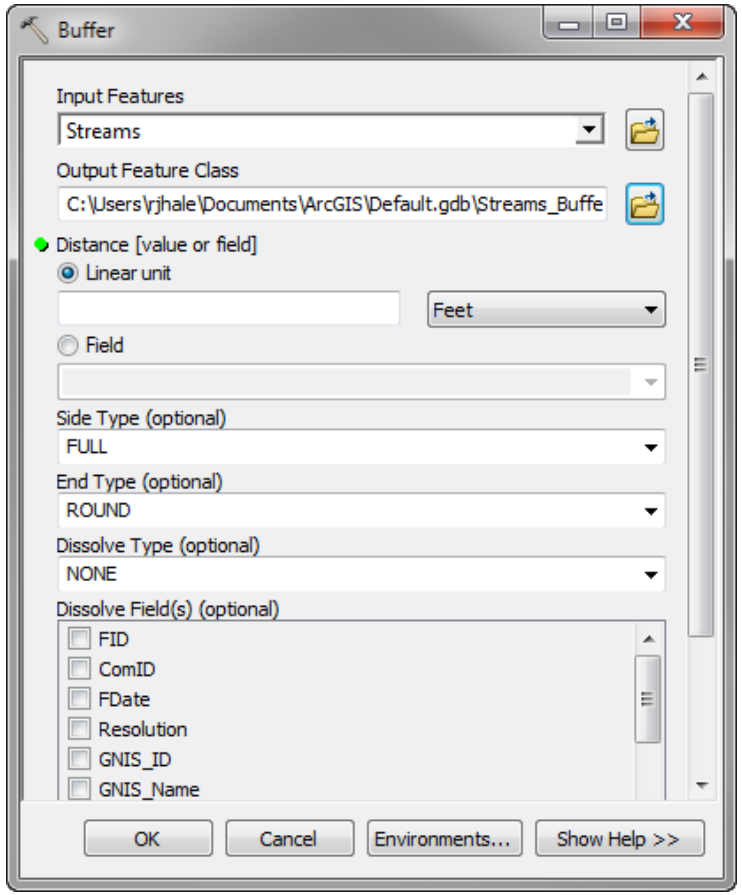
15. Buffer the streams **200 Feet**.

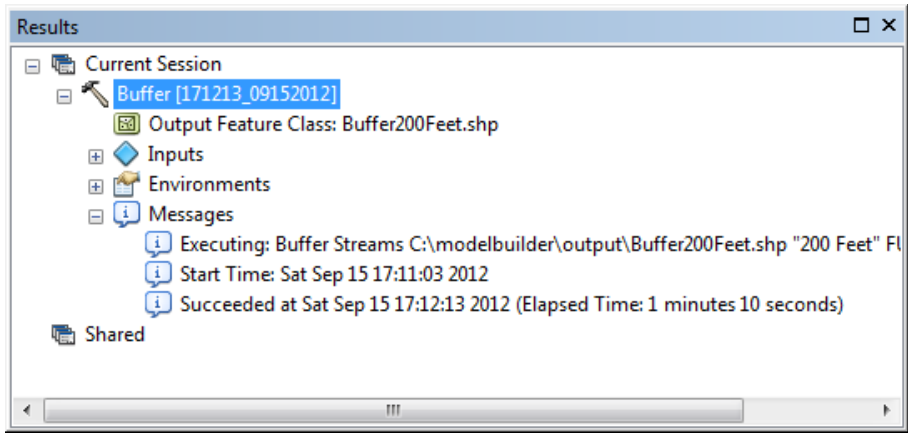
16. Save the output - **Buffer200Feet** in the output
    directory. Set the **Dissolve Type** to **All**.

17. Check the **Results** window by click on the
    Geoprocessing menu and going to Results.

18. Can you save to Python code from the results window? Right Click and see if you can

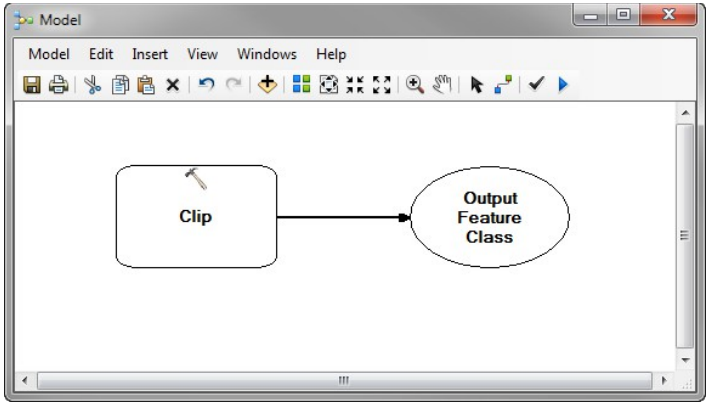
19. Save your MXD!





Introduction to Model Builder and Python

Chapter 3: Modelbuilder



3. Models

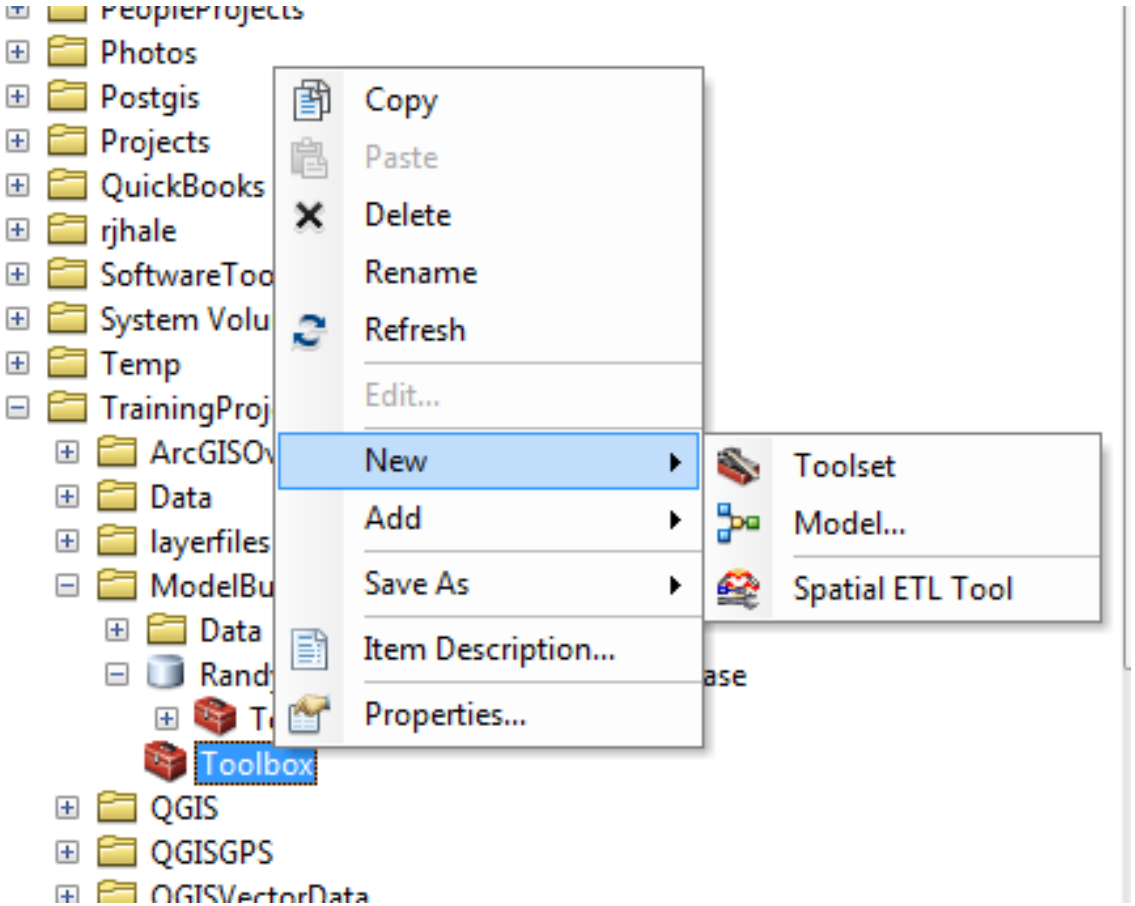
- Geoprocessing processes can be saved to use later
- Geoprocessing tools can be linked together to form a process
  - A Model
- Different tools can be linked in one model

Toolbox

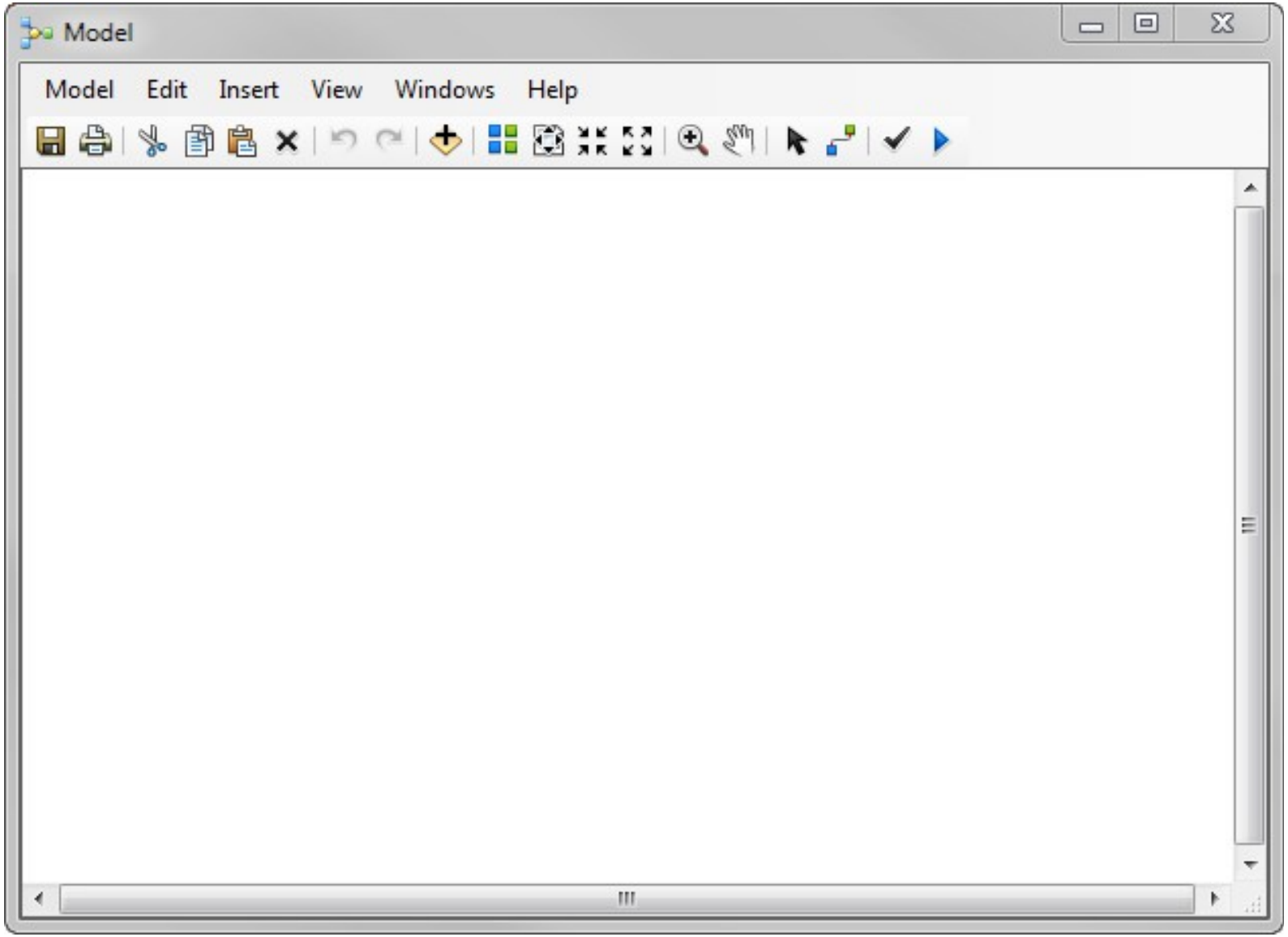
- In order to save a model you must create a new toolbox
- Toolboxes can be created almost anywhere in ArcMap/ArcCatalog
  - Create directories to place toolboxes
  - Can be placed in geodatabases
    - File-based
    - Personal-based
  - SDE

Toolboxes and Models

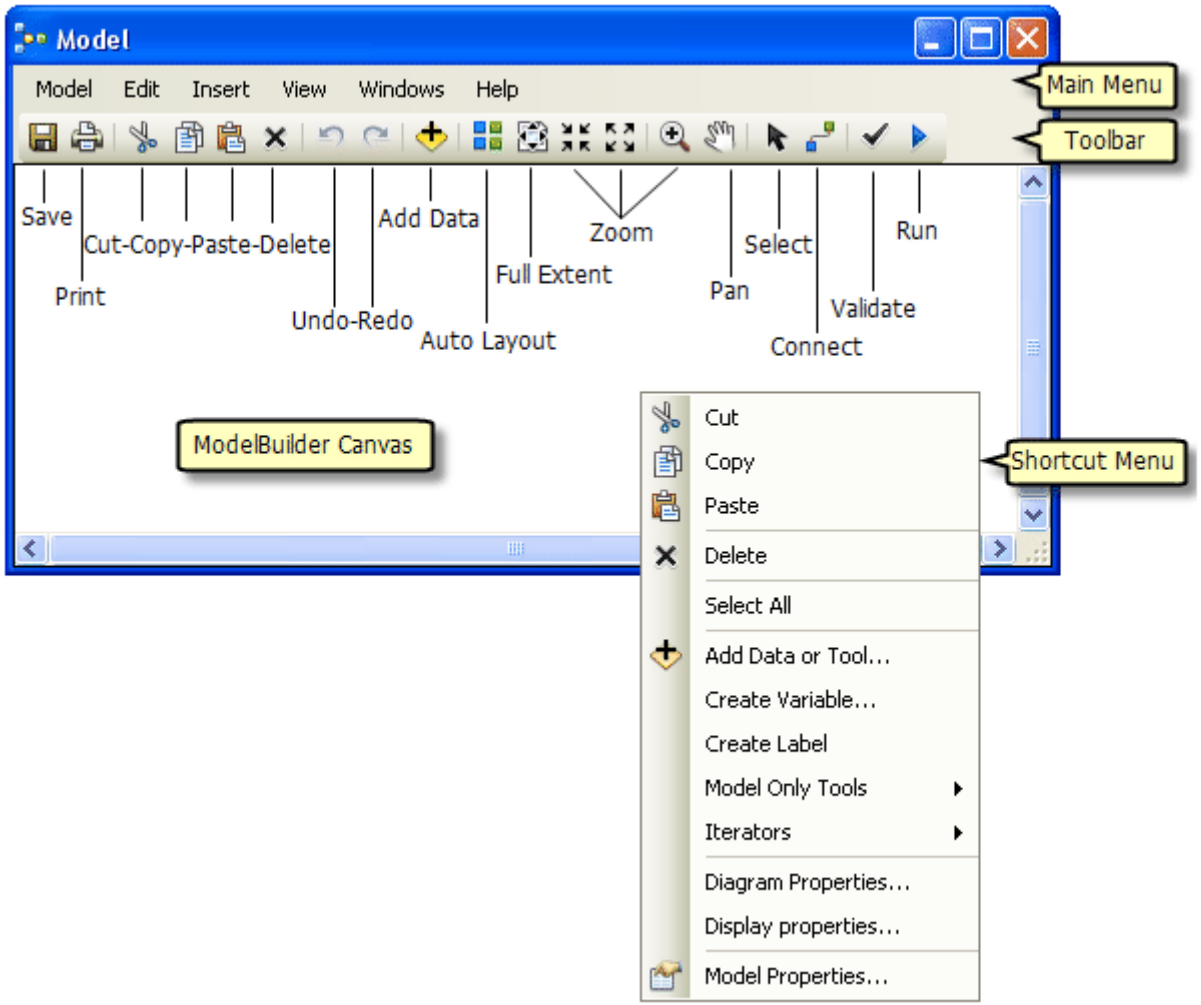
- Once a Toolbox is made -> Create a Model



First Opened - Boring



Model Builder Interface

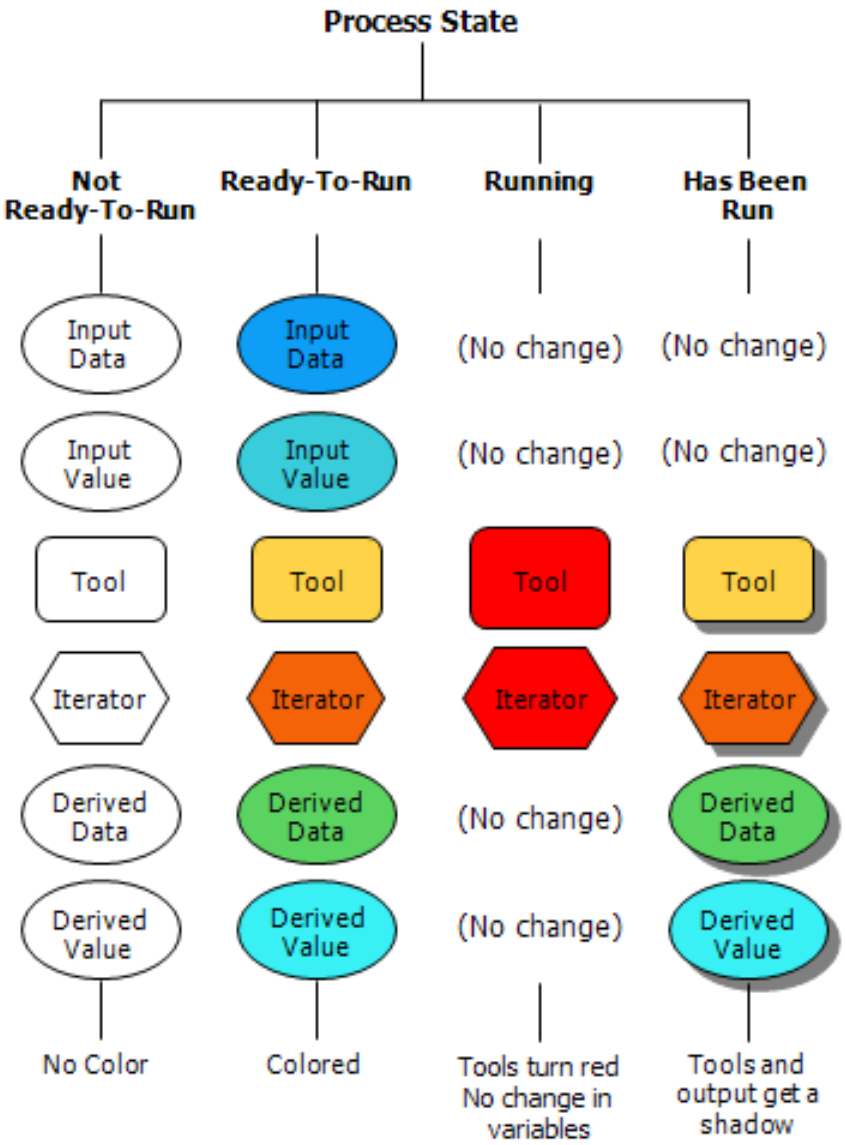


Creating a Model

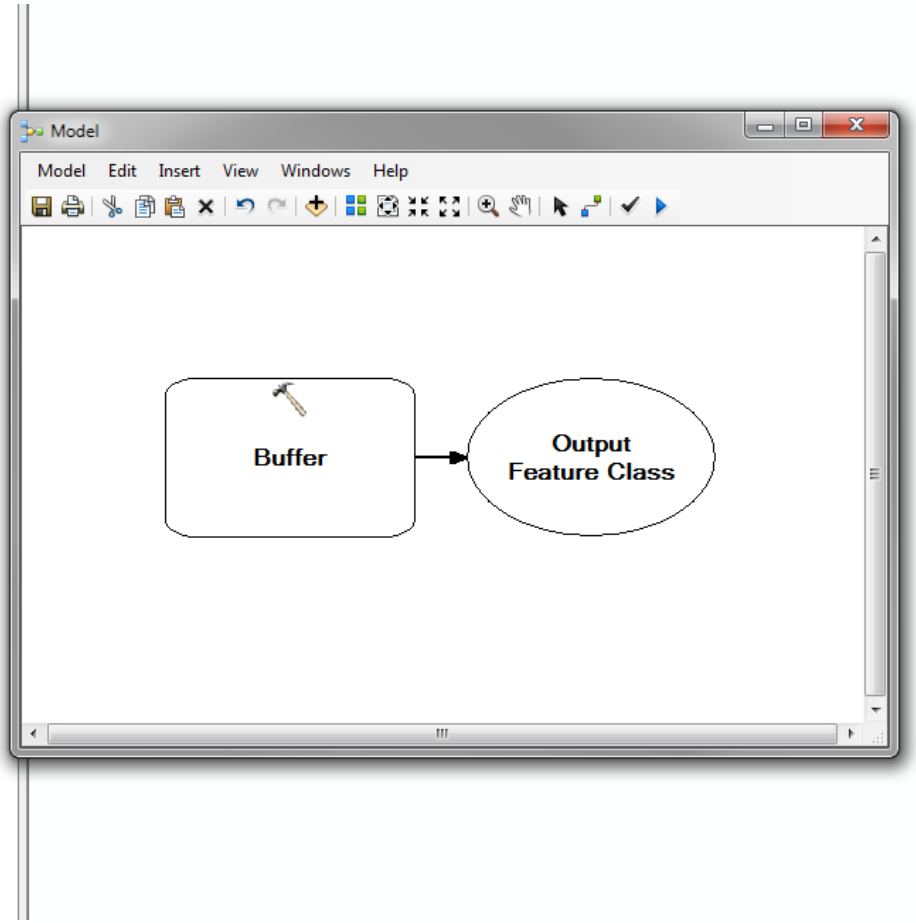
Drag and drop tools from ArcToolbox onto the Model Builder Canvas

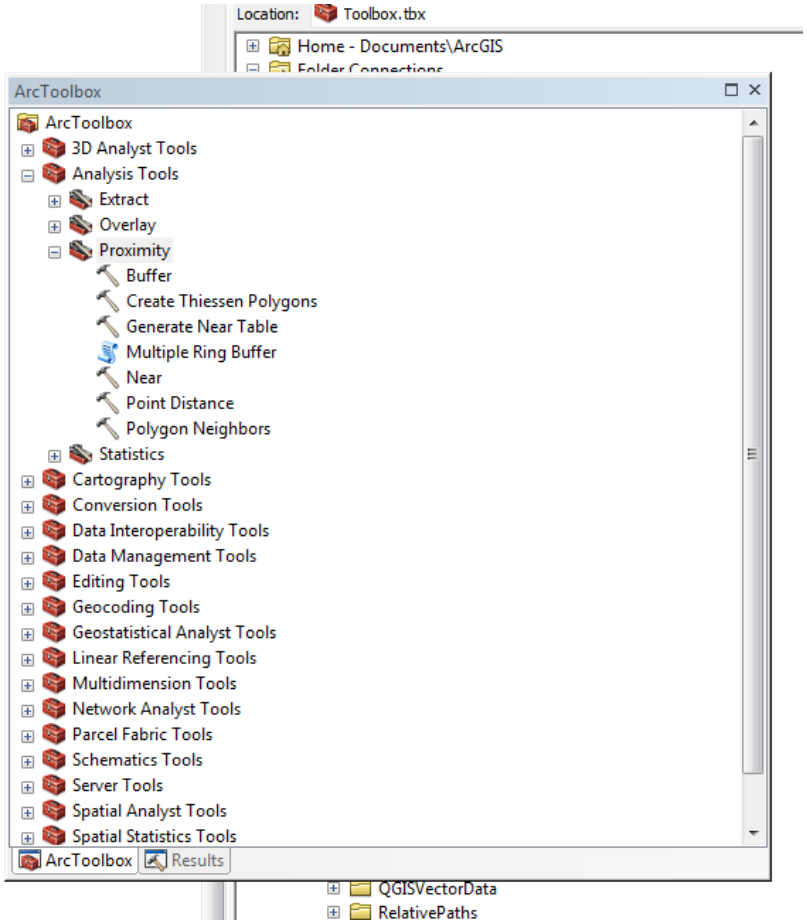
- Tool processes take shape and color according to purpose
- Shadows mean a tool has run
- Processes flash red when running

Symbology

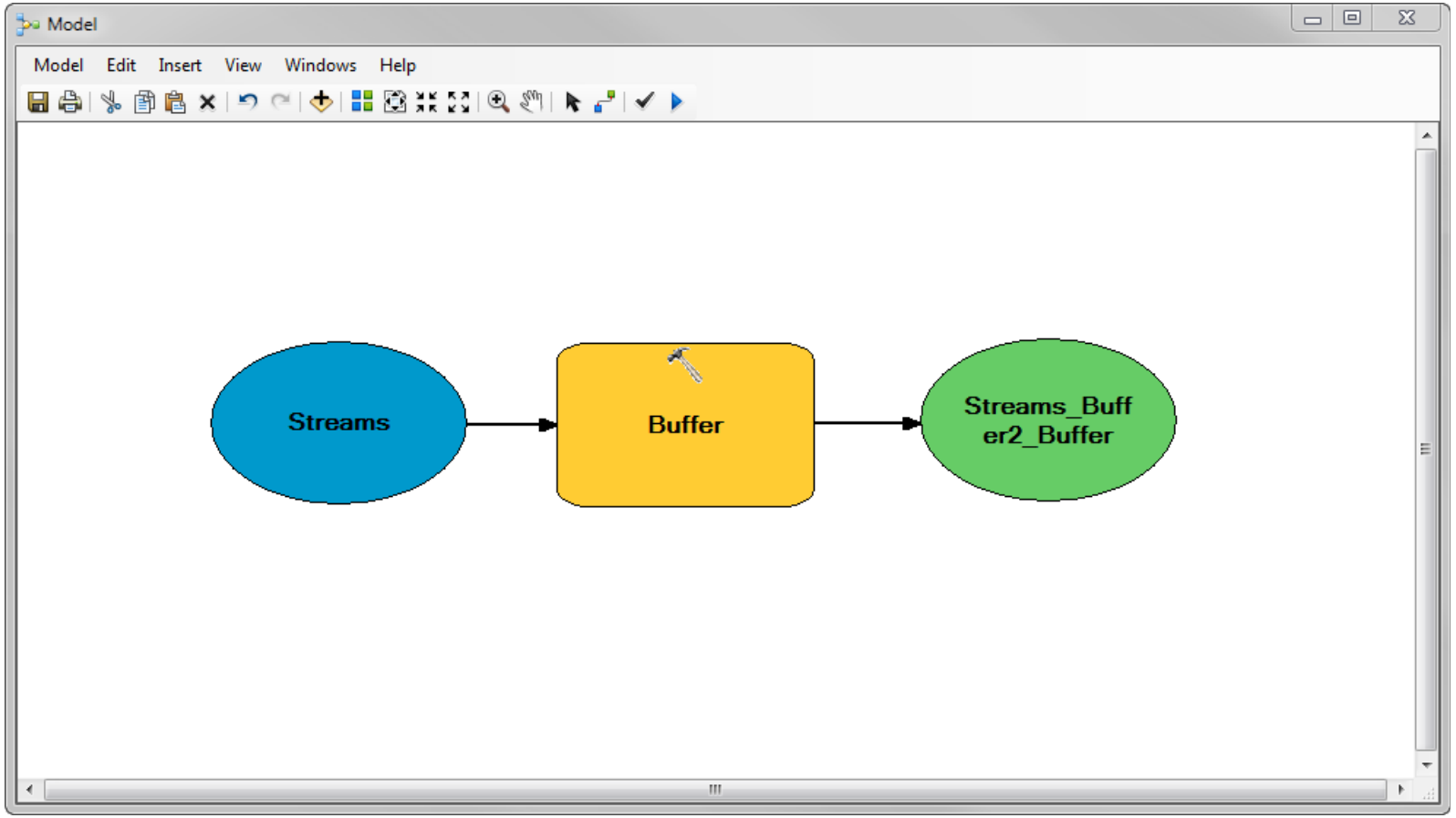


Model with no Inputs

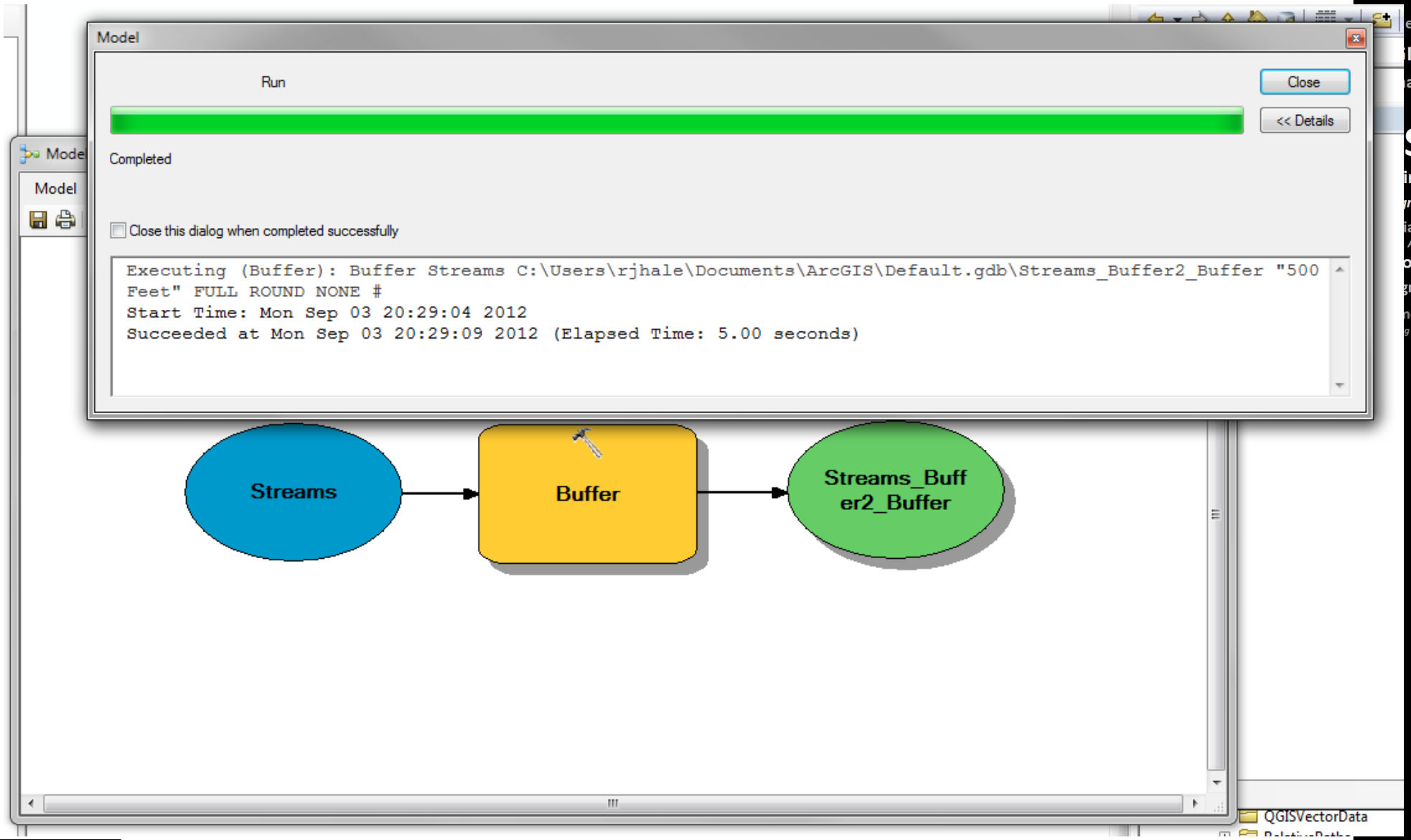


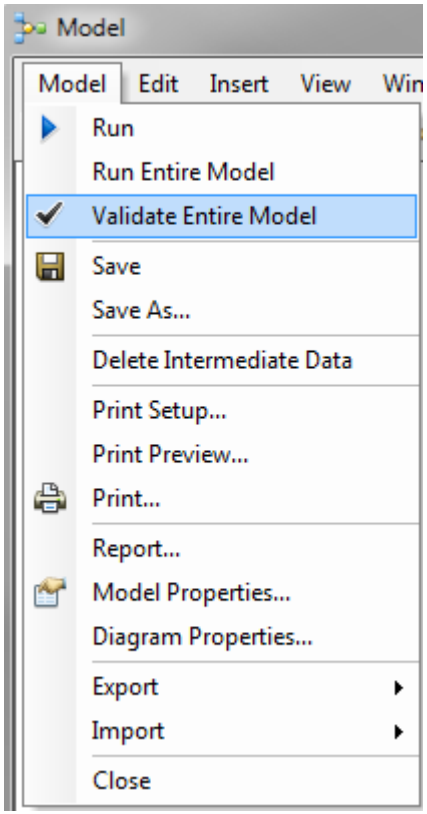


Fill in the Parameters



Hit the "Run" Button





Results

- Once the Model runs it gains "shadows"
- Model must be validated to run again from beginning.

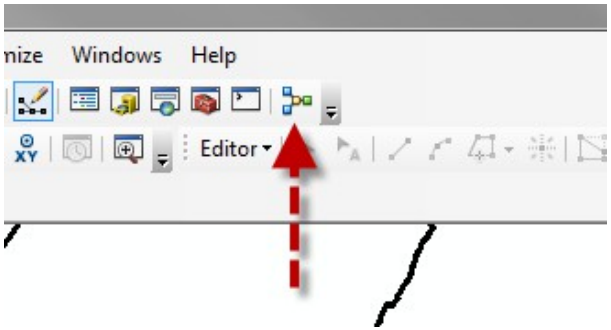
Exercise 3

- Build a simple model
- Save the model to be shared
- Work with Results Window
- 20 Minutes

Exercise

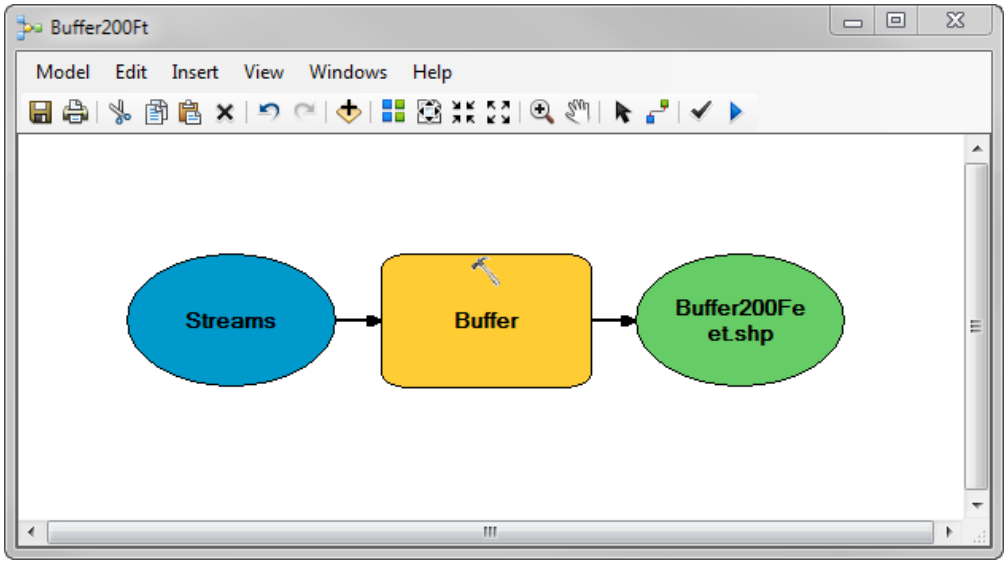
1. Hopefully you have your MXD open from the previous exercise. If not open it.

2. Open a **New Model** by clicking on the Model Builder Icon in ArcMap.



3. Save that Model to the Toolbox you created in the previous exercise. Name it **Buffer200Ft**

4. Drag the Buffer Tool into Model Builder. Double-click the Buffer tool and Fill out the values as you did in the previous exercise. You want a 200-Foot Buffer and the dissolve option set to ALL



5. Save the Model. Click "Run"

6. What color indicates the Model is Running? What has been added or changed with the model ?

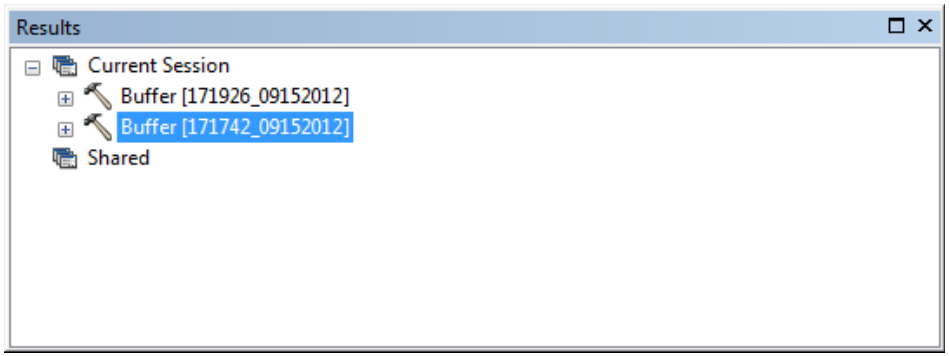
7. Once a Model has been run it needs to be validated. Click Model -> Validate Entire Model to prepare it to run again.

Exercise

8. Check the **Results Tab** - Was your Model recorded?

9. Create a **New Empty Model**. Save it and Call it **ResultsBuffer**.

10. You should have a buffer from the previous exercise in the results window. Drag a buffer from the previous Exercise out of the results window into the Model. What happens?



11. Find the **Clip** Command in ArcToolbox. It is located under **Analysis Tools -> Extract**.

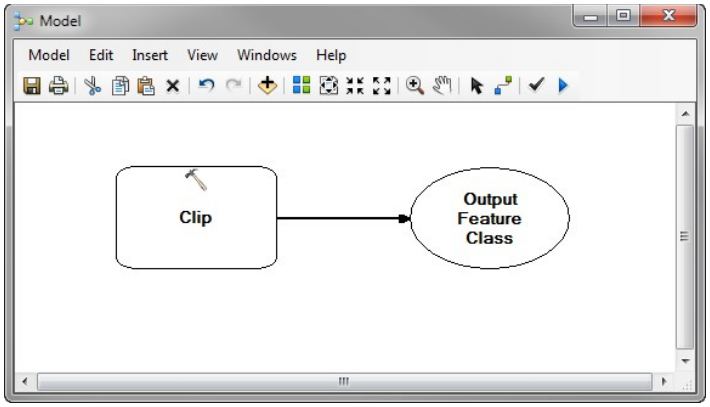
12. Right-click the tool and click **Copy**.

13. Go to your Toolbox, Right-click and select **Paste**. You have now saved a copy of the Clip Tool to your Toolbox. If you have a project where the user only needs certain tools they can be placed here.

14. Be sure all your models are saved!

Introduction to Model Builder and Python

Chapter 4: Variables & Parameters

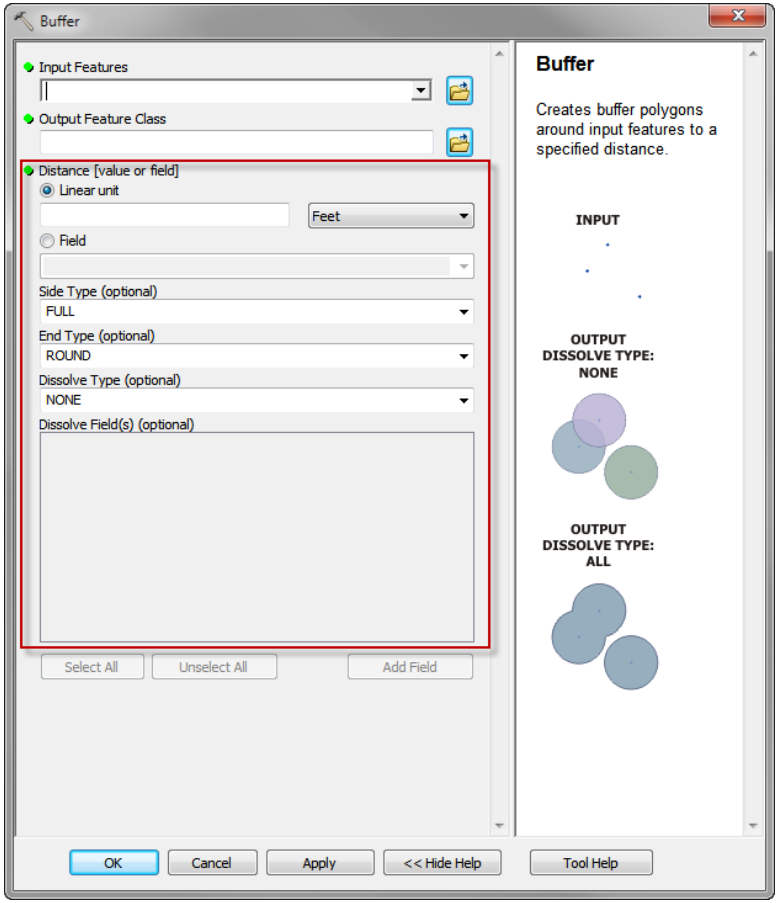


4. Variables and Parameters

- Every tool has Parameters
  - Parameters allow the user to make changes to a tool.
- Parameters can be exposed as Variables
  - Variables can be changed by users

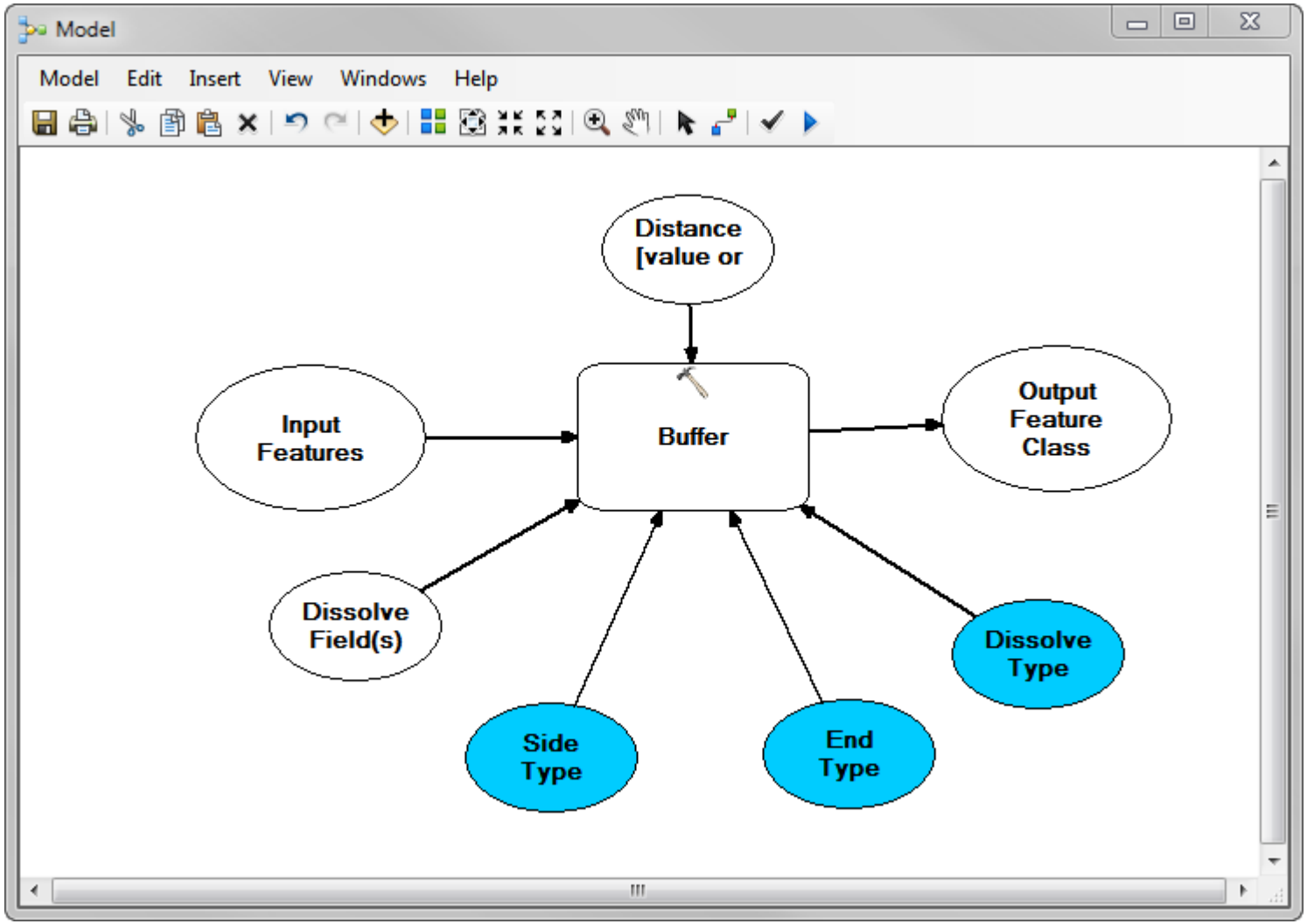
Parameters

- Every Geoprocessing tool has Parameters. Parameters control how the tool conducts itself



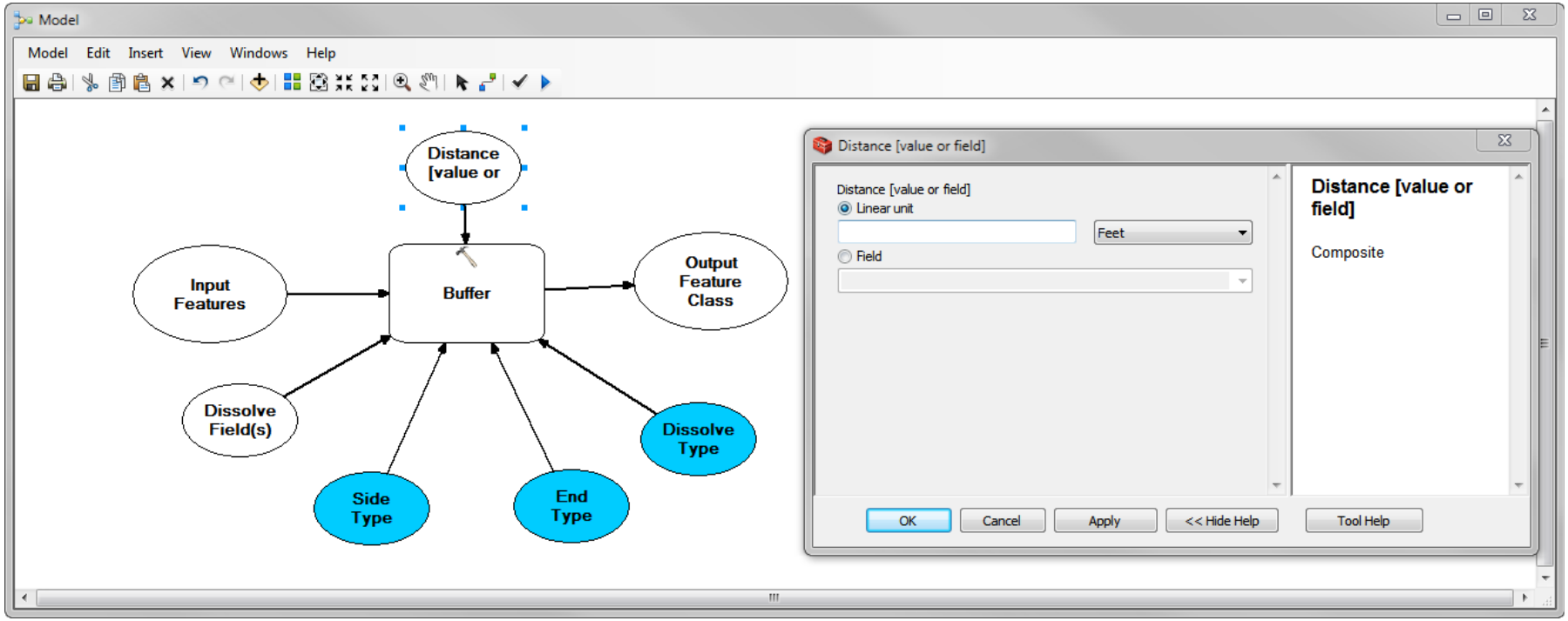
- The Buffer tool has eight Parameters
  - input
  - output
  - Distance
  - Units
  - Side Type
  - End type
  - Dissolve
  - Dissolve Fields

Parameters exposed

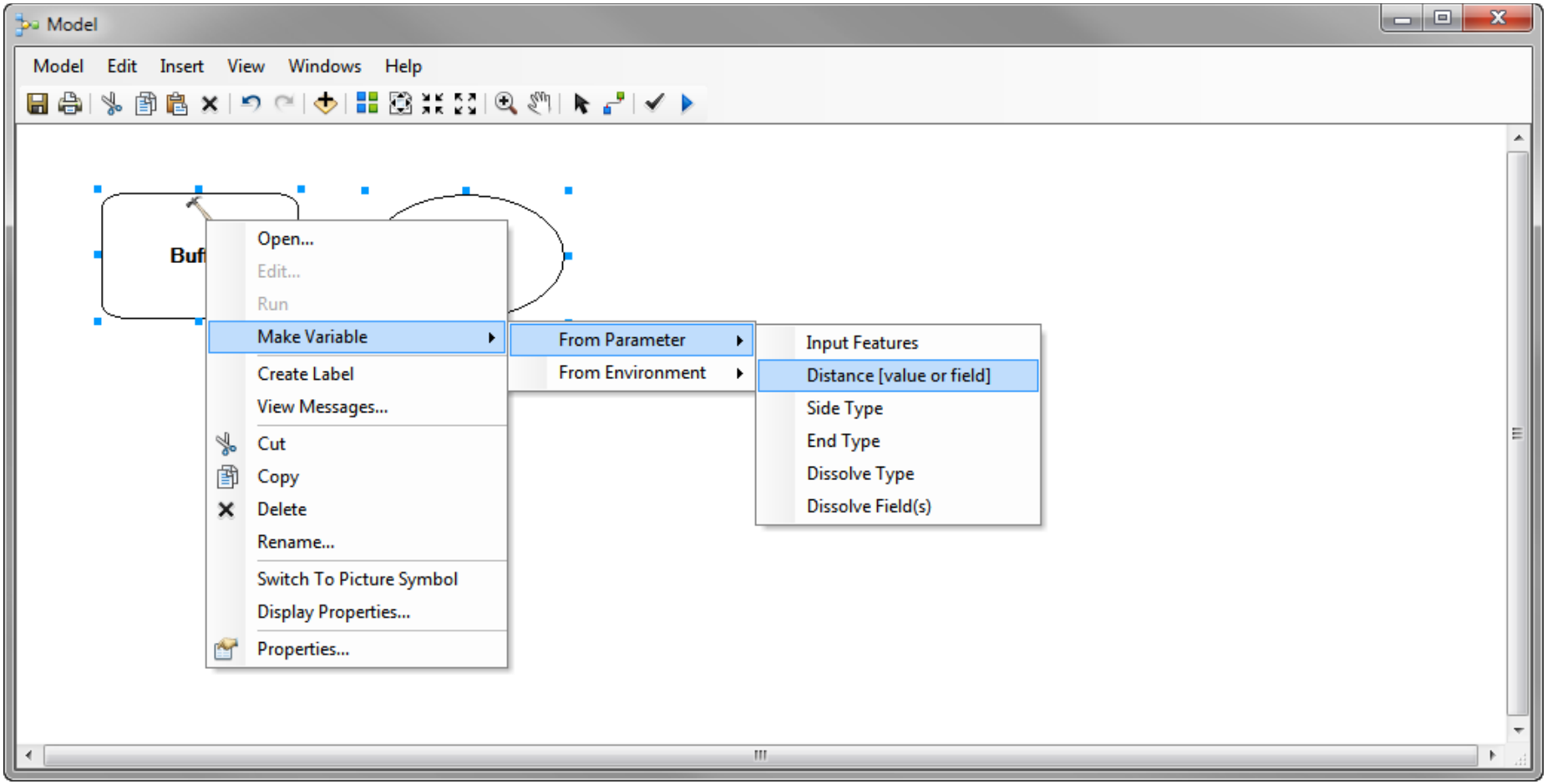


Parameter

- Double-clicking the Parameter will allow you to set it.



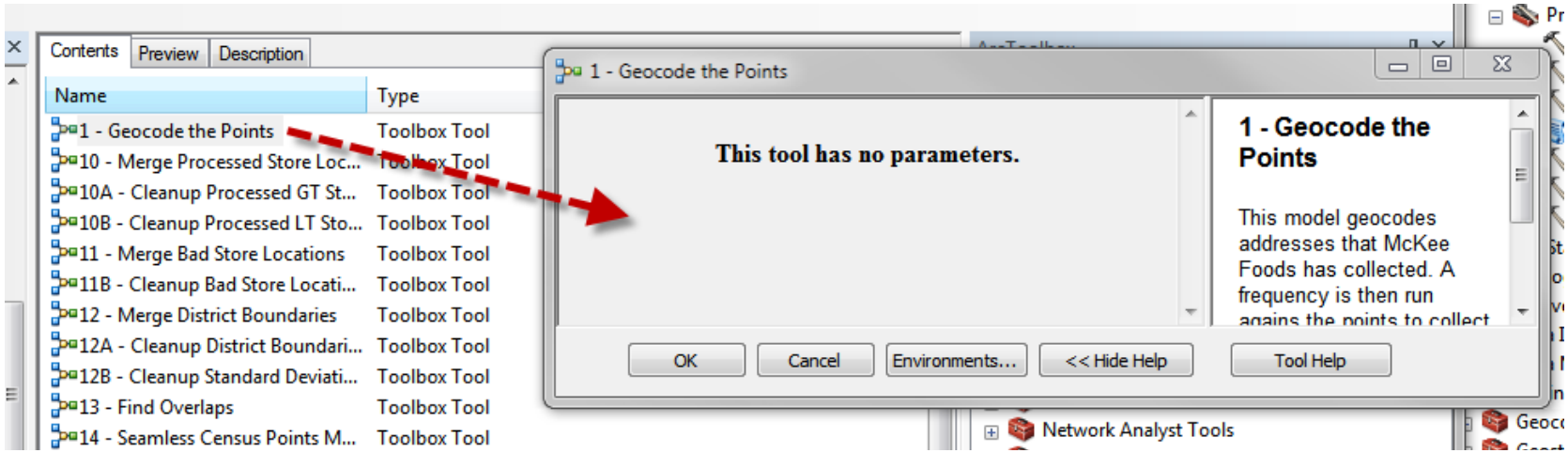
Parameters can be exposed as variables in Model Builder



Why expose a Parameter?

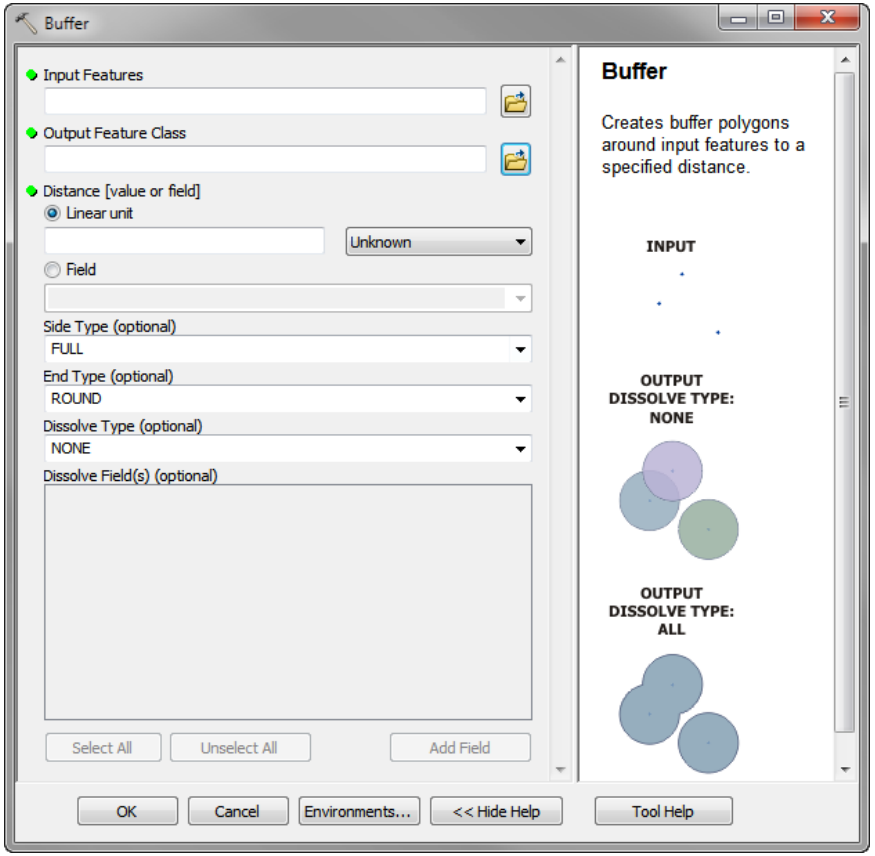
Make it a Variable

- Variables allow for user interaction
- Models can be shared and allow some flexibility for the end user with Variables
- Models come with a User Interface - Variables show up on that GUI

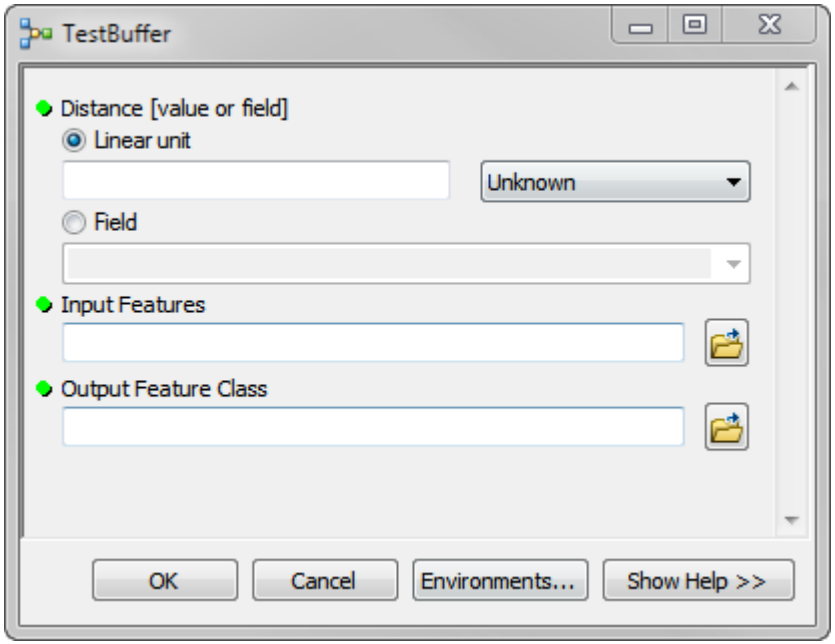


The Buffer Tool

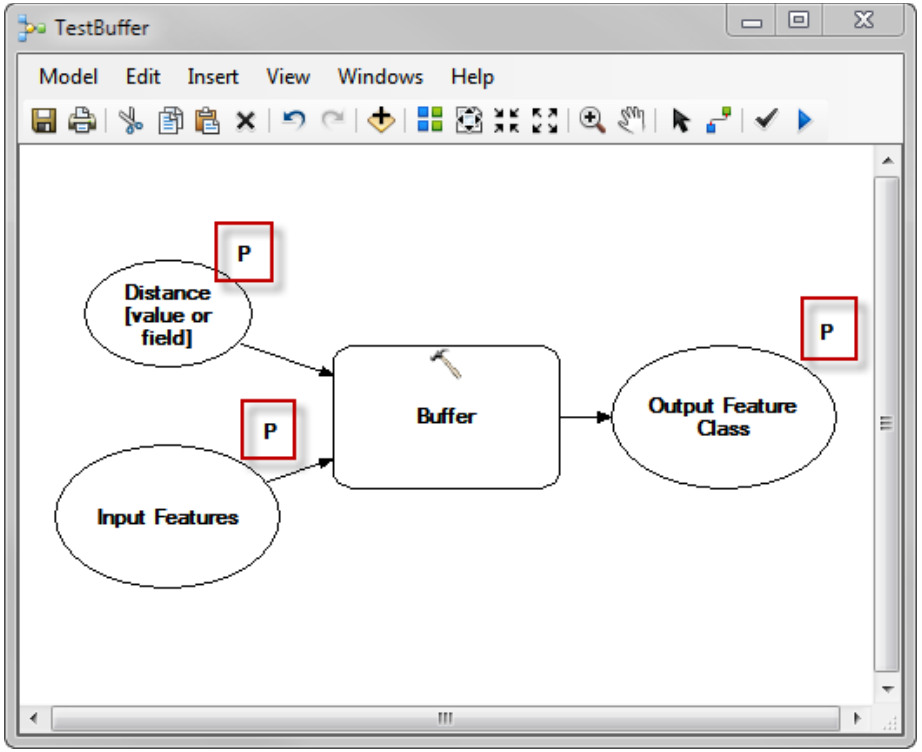
- From ArcToolbox

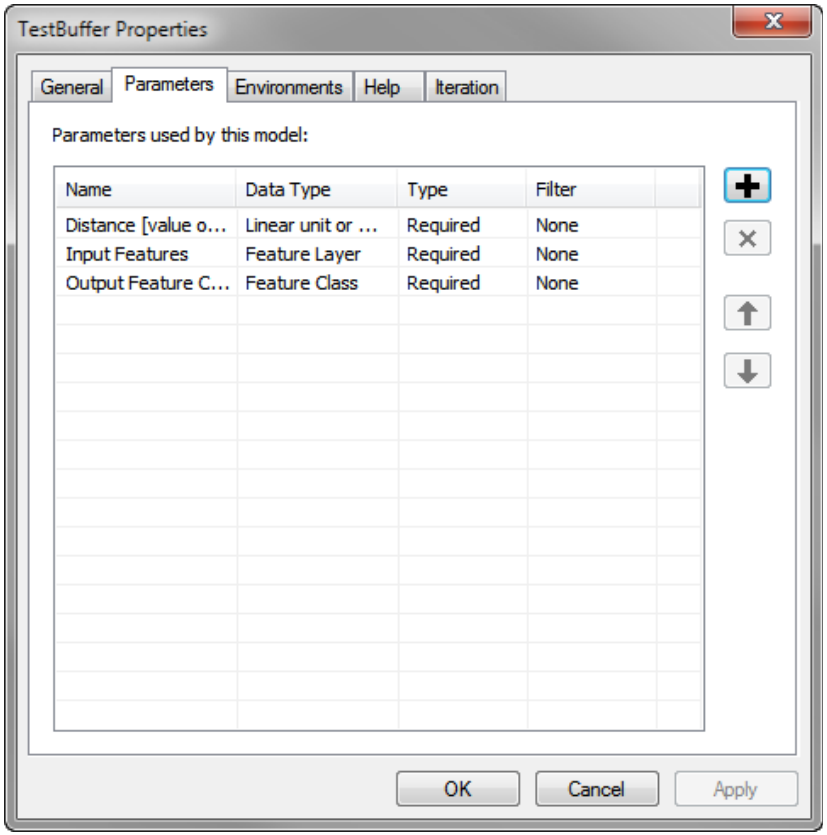


- As a Model with three parameters



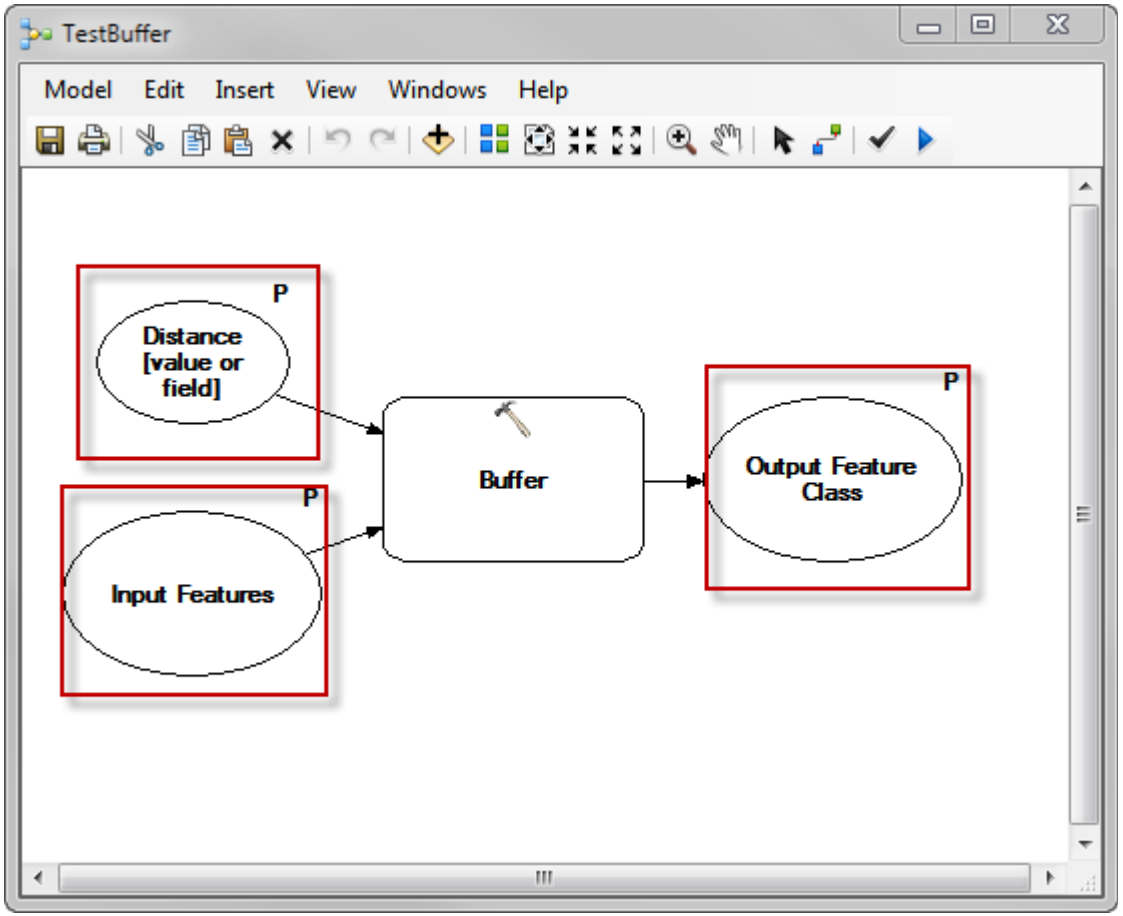
Setting Variables





- Right Click and make it a parameter

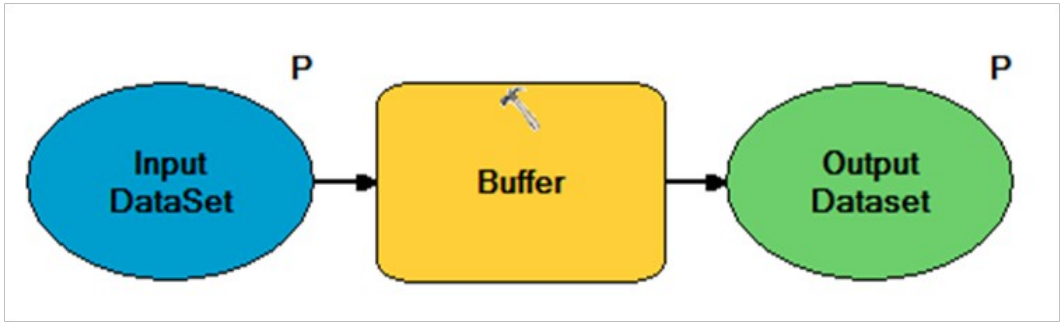
Rename Parameters



- Renaming Parameters renames them in the GUI
- Can make them easier to understand for users

Exercise 4

- Control and expose tool variables
- Set variables to parameters
- 20 Minutes



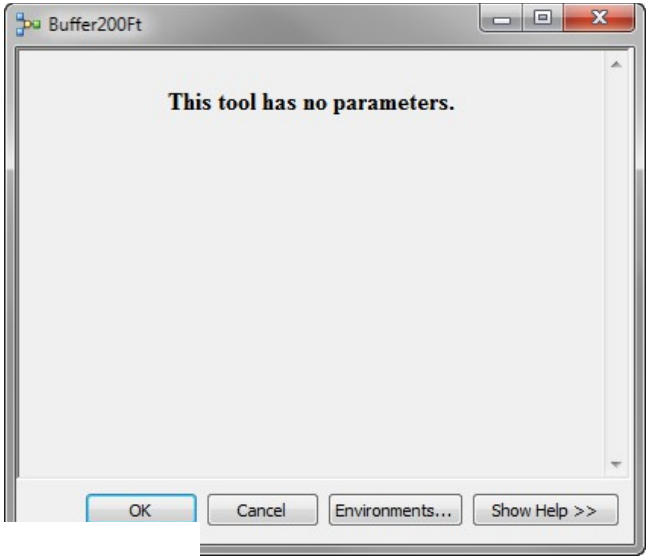
Exercise

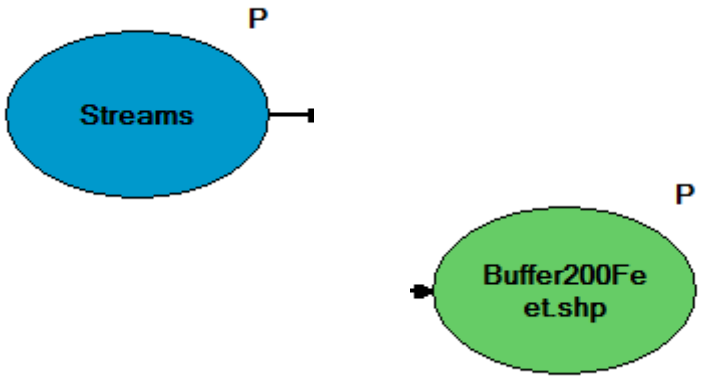
1. Double-click the **Buffer200Ft** Tool in your Toolbox.We need to add Parameters to the Model.

2. Click Cancel and then Right-click the Buffer200Ft Model and click **Edit**. You should have the Model Builder interface back in front of you.

3. Right-click the Streams (or **Input**) and make it a **Parameter**.

4. Right-click the **Output** and make it a **Parameter** also.





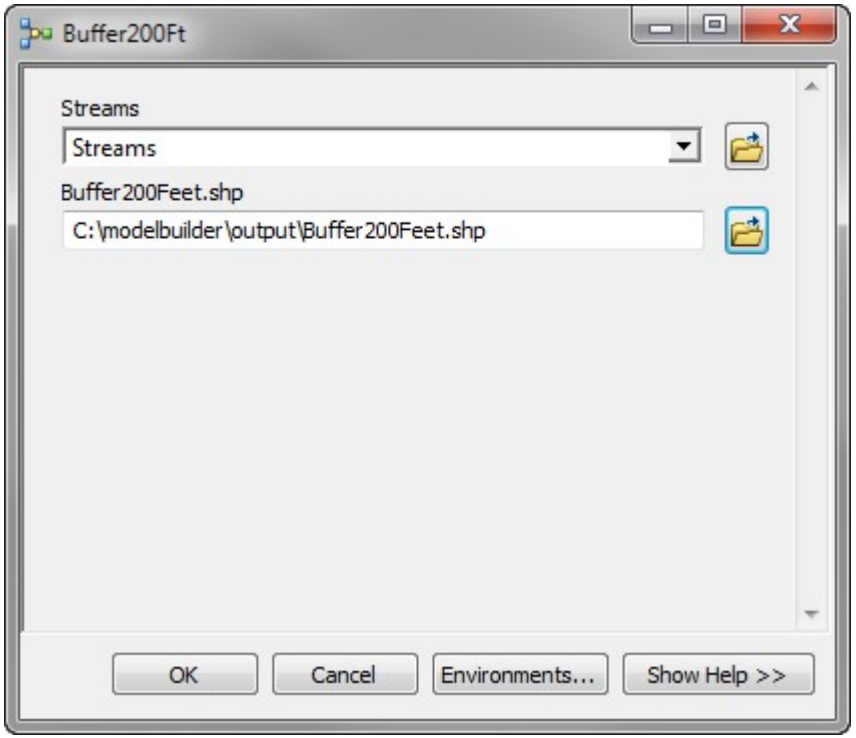
Exercise

5. **Save** the Model Double-click it again and see what changed.

6. Click **Cancel** and begin editing the Model once more.

7. Right-click the **Streams** and **Rename** it to **Input Dataset**.

8. Right-click the **Buffer200Feet.shp** dataset and **Rename** it to **Output Dataset**.

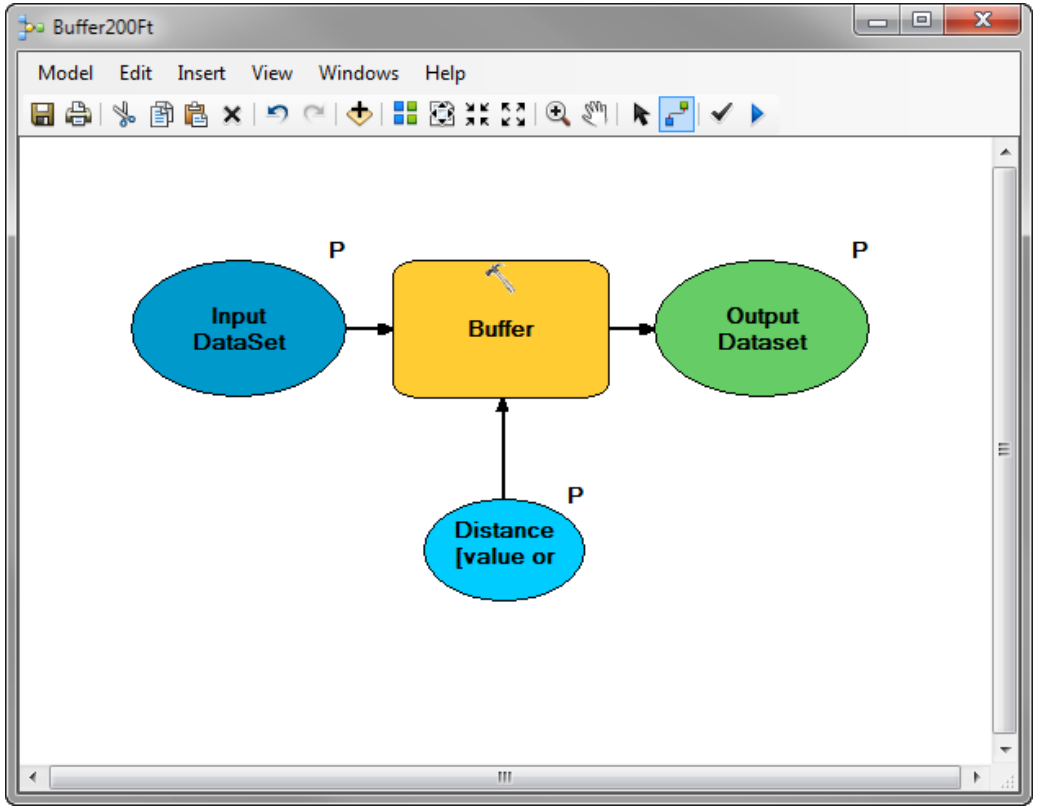


Exercise

9. Right-click the square **Buffer Tool** and make a **Parameter from the Variable**. Right-click and
   make it a **Model Parameter**.

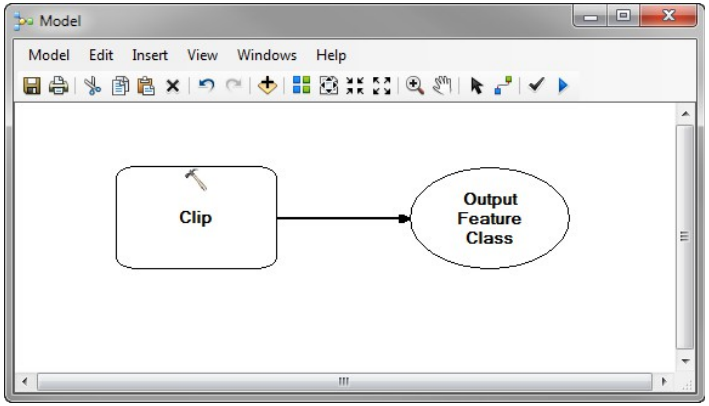
10. Save the Model.

11. Double-click the Model in the Toolbox.



Introduction to Model Builder and Python

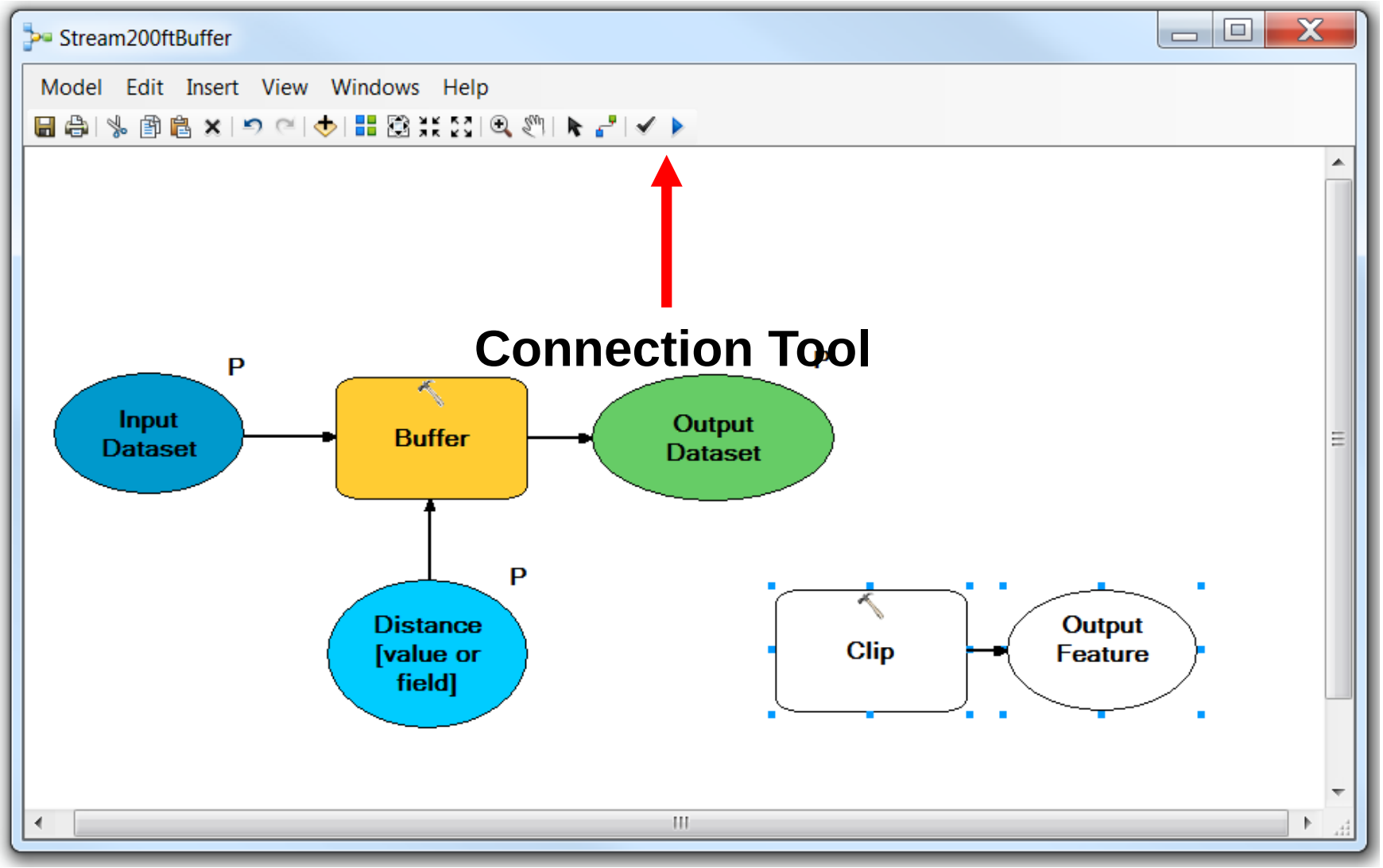
Chapter 5: Connecting Models



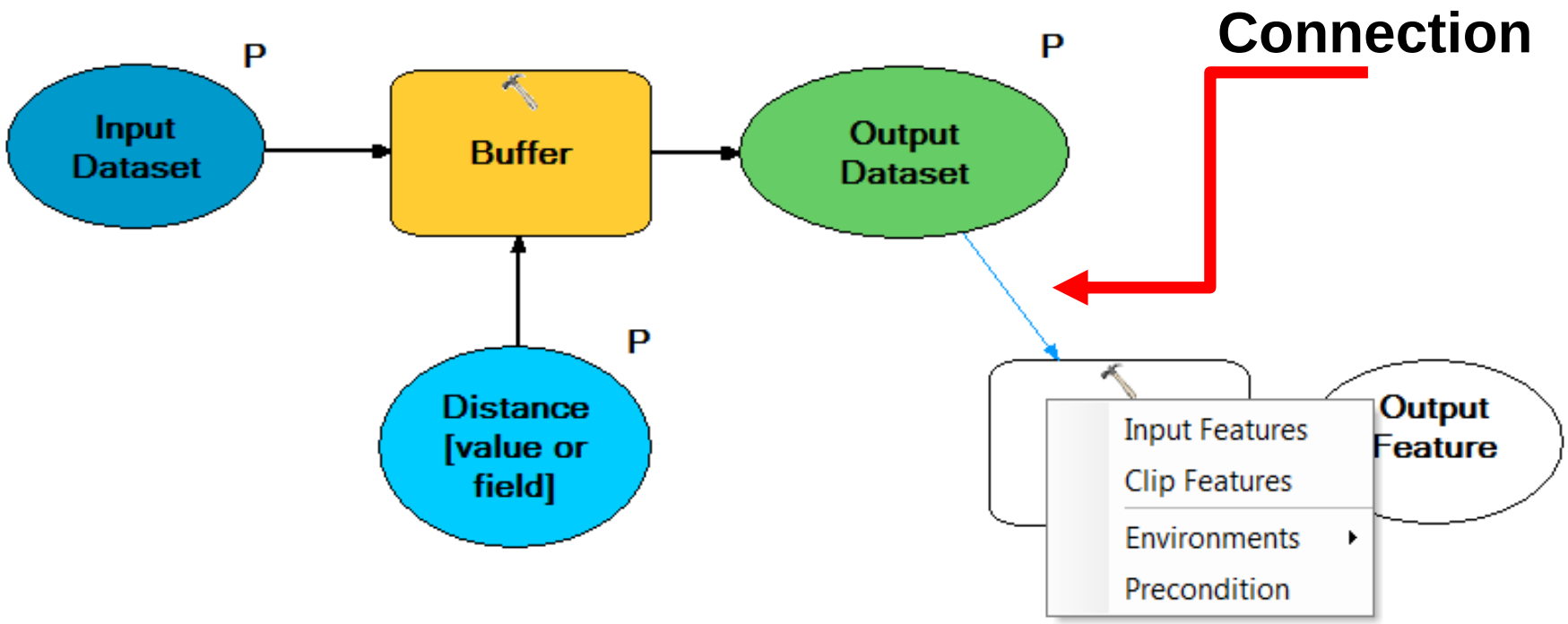
5. Connecting Models

- Tools Can be linked together
- Outputs of one tool can be inputs for another tool
- Tools order is controlled by Preconditions

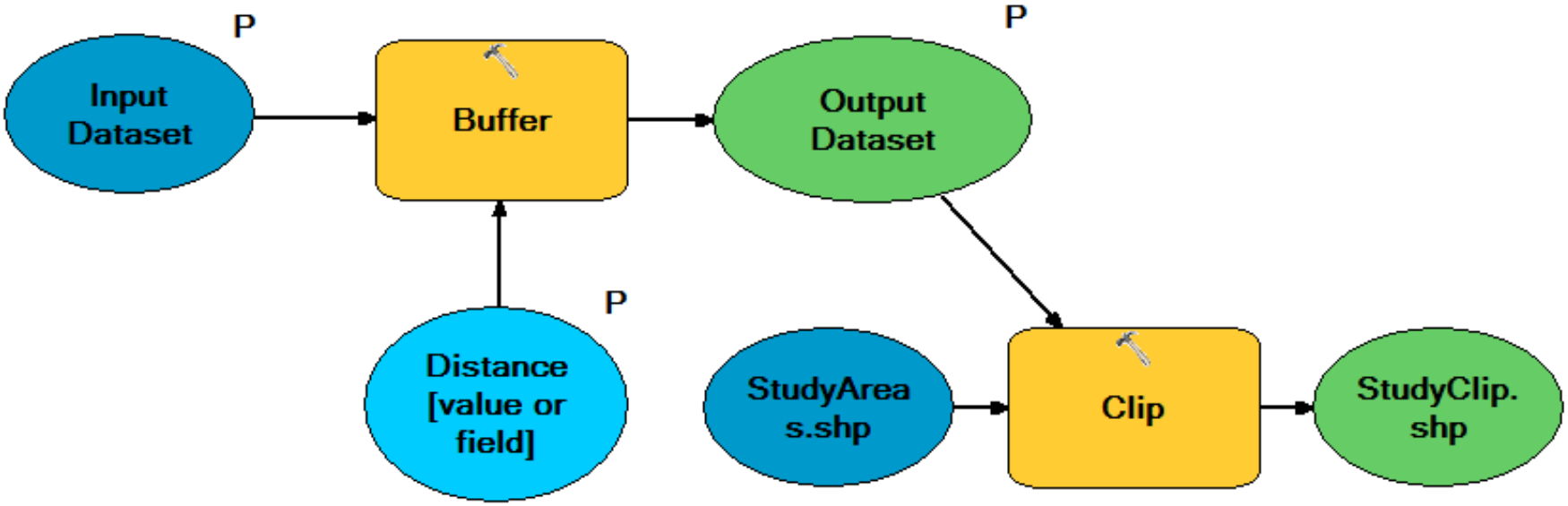
Connect



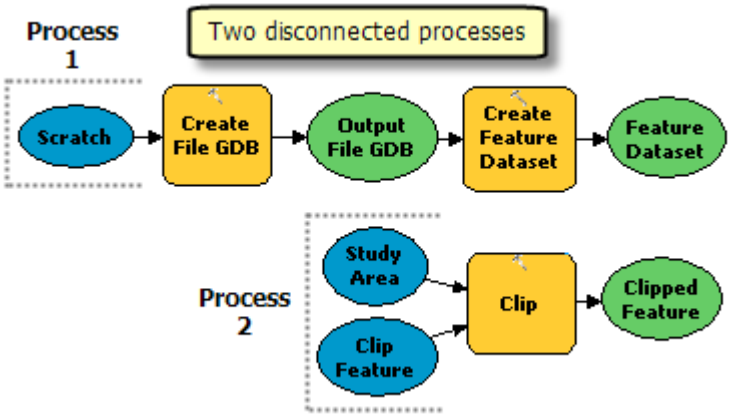
Connect



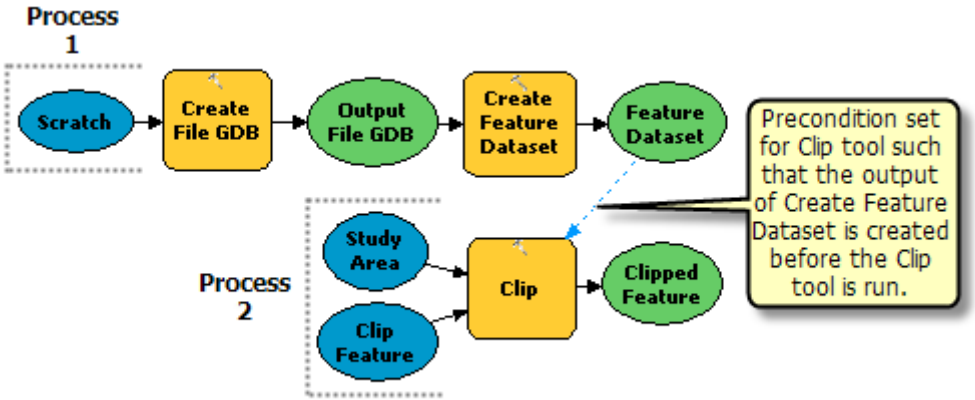
Connect



Preconditions

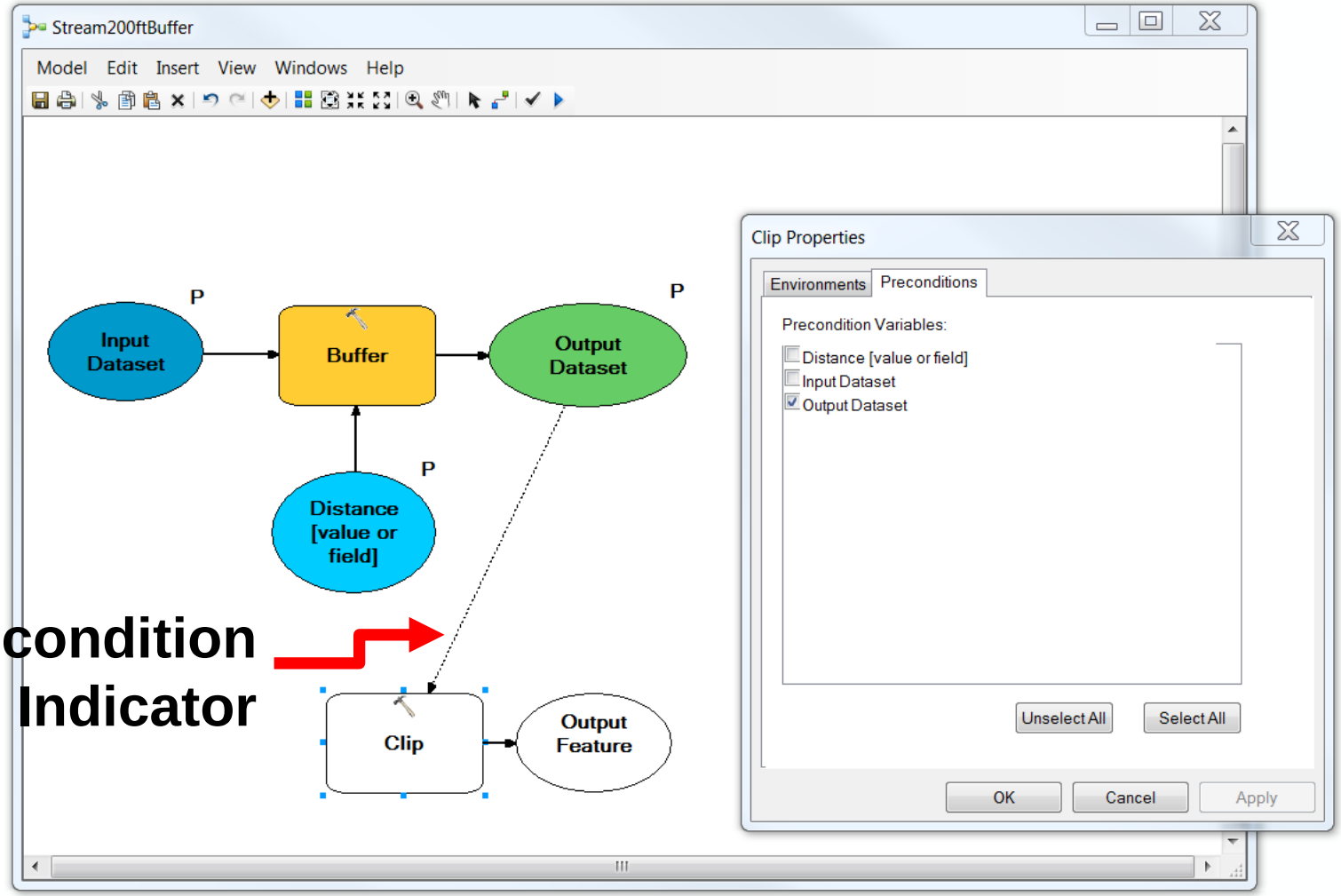


Preconditions make sure one element runs before the other.



Setting a Precondition

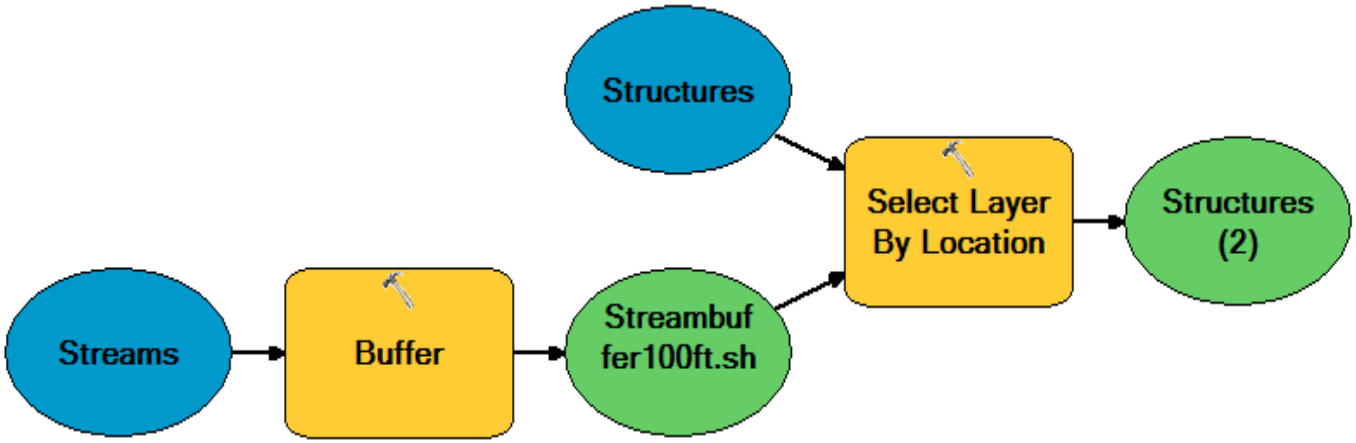
- Clip will not run until buffer runs



Precondition Indicator

Exercise 5

- Connect two tools together using different methods
- Control order in which tools are run using preconditions
- 20 Minutes

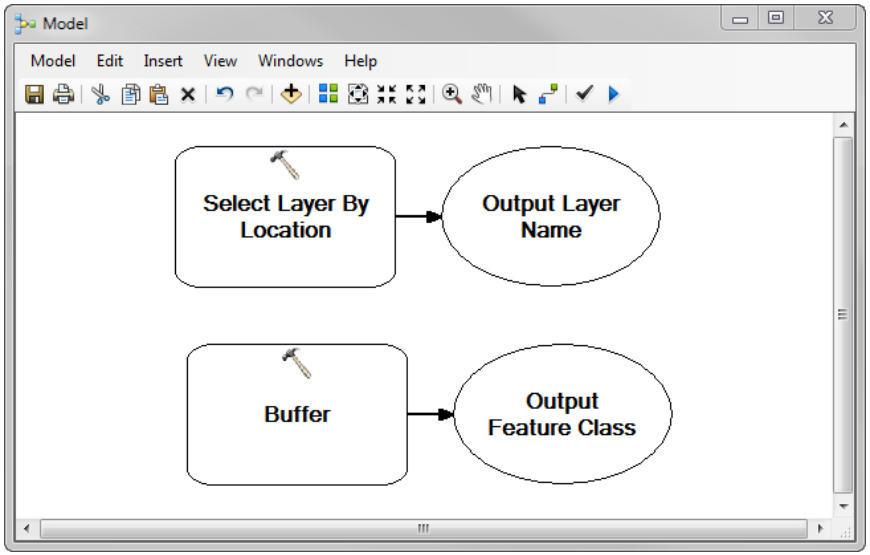


Exercise

1. Open your MXD from the previous exercise if you closed it.

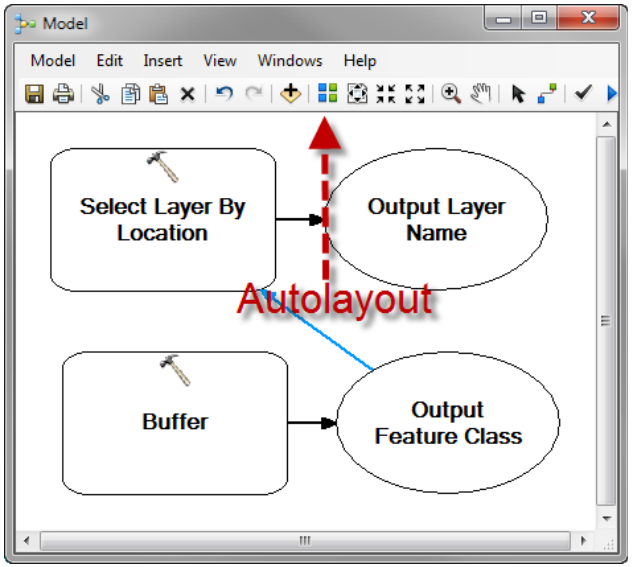
2. Open a **New Model** by clicking on the Model Builder Icon in ArcMap.

3. Add a Buffer tool to the model. Also add a **Select by Location** tool to the Model. Use the **Search** for tools menu to locate it. This menu is located under the Geoprocessing Menu in ArcMap.



4. Connect the **Output Feature Class** to the **Select Layer by Location** tool using the **Connect** icon. Be sure you choose selecting features.

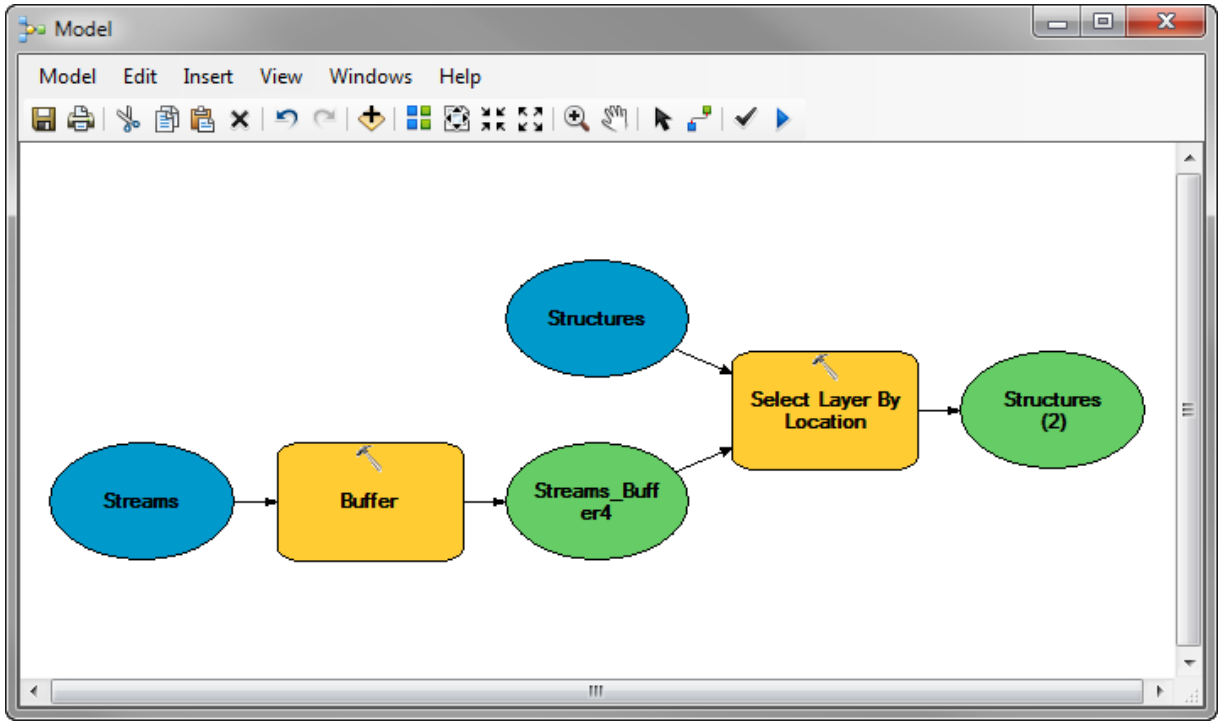
6. Click **Autolayout**. Notice your Model will get "Re-arranged".



Exercise

7. Start filling out features in the Model. You want to Buffer the streams 100 Feet. The Input feature layer in the Select By Location tool will be the **Structures**.

8. Click **Autoarrange**.



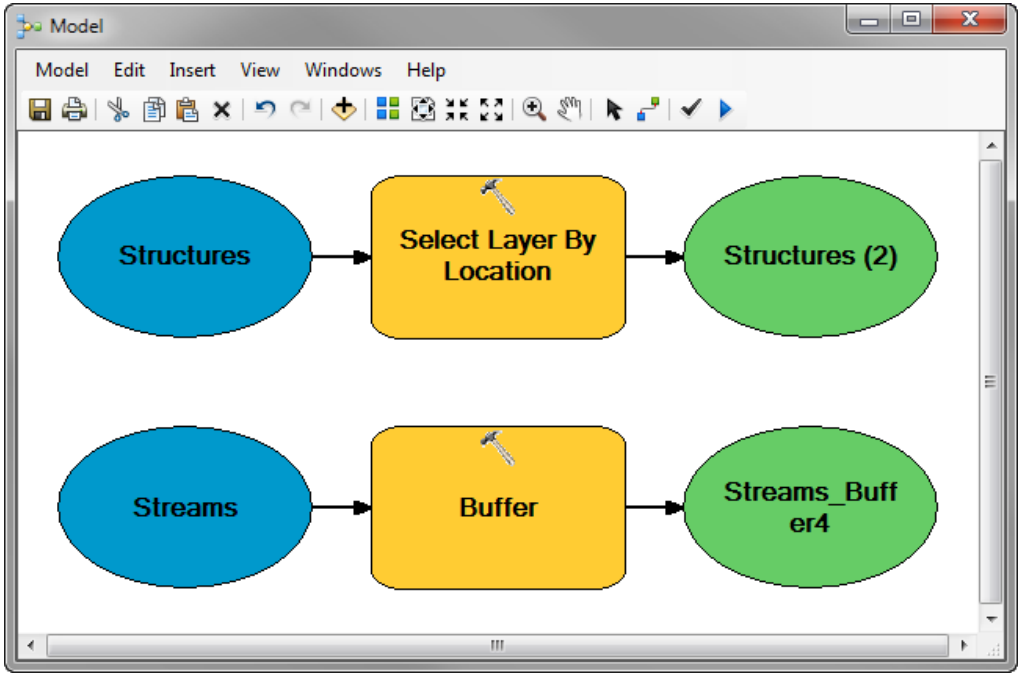
9. Run the Model

10. How many Structures are within 100 Feet of the Streams?

Exercise

11. Delete the connection between the two tools.

12. Click Autoarrange.



13. Double-click the **Select by Location**. Set the selecting features to be the **Output of the Buffer** command

14. What happens?

Exercise

15. Save your Model as **BufferSelection100Ft**.

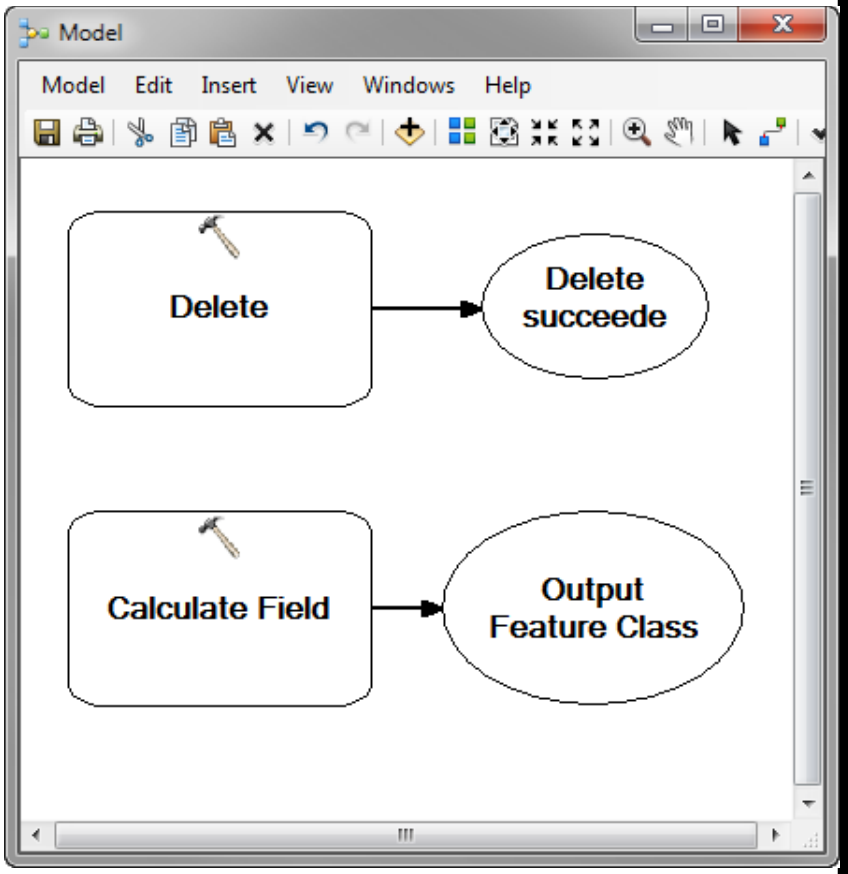
16. Create a **New empty Model**. A Model doesn't have to contain connected tools. It can contain just a series of tools that need to be run at the end of a project. Copy the **Calculate Field** Tool and the **Delete Management** tool into your model (using the **Search** for tools).

17. You need the tools to run in a certain order. Right-click the **Delete** tool and select Properties. Go to the **Precondition Tab**. Select **Output Feature Class**. Click OK.

18. What happens?

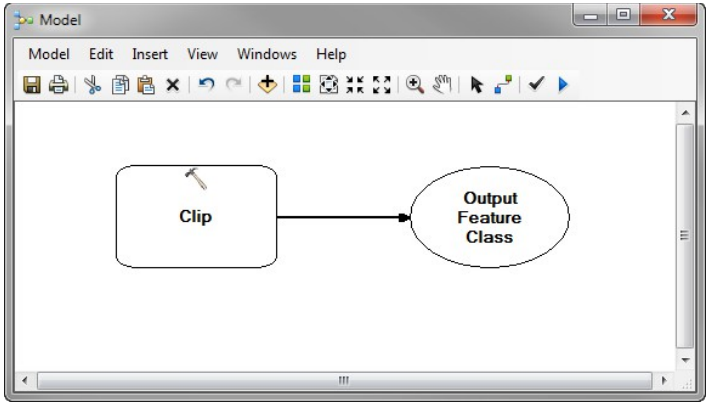
19. The Tools will now run in a certain order.

20. You don't have to save this model. Just close it.



Introduction to Model Builder and Python

Chapter 6: Iterators & Model Only Tools



6. Iterators and Feature Only Tools

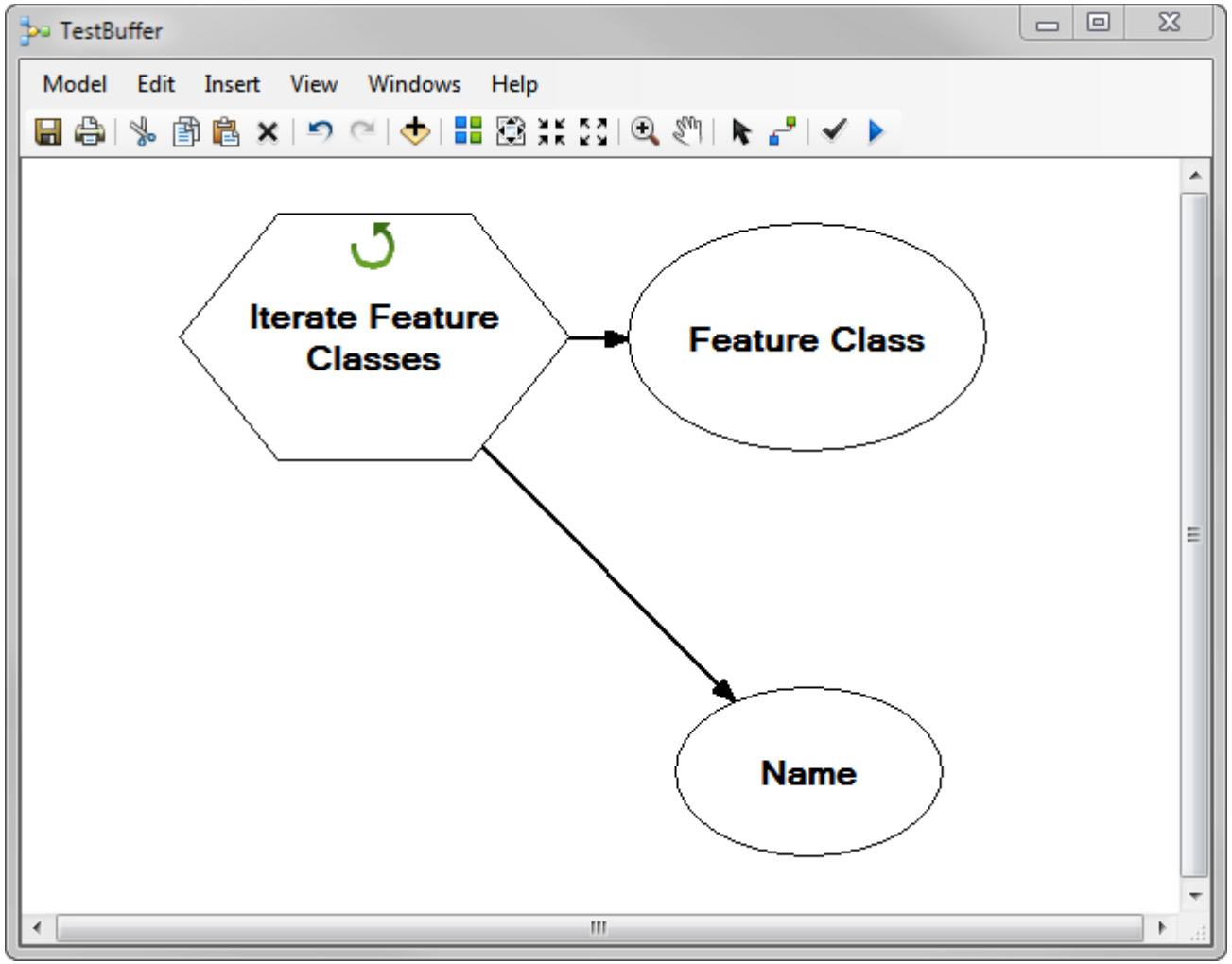
- Iterators
  - Looping
  - Loop through data (vector, raster).
  - Loop through tables

- Model Only Tools
  - Collect Values
  - Calculate Values
  - Parse Data

Before Iterators

```
import arcpy
from arcpy import env
import os

# Set the workspace.
#List all of the feature classes that start with 'G'

env.workspace = "D:/St_Johns/data.gdb"
fcs = arcpy.ListFeatureClasses("G*")
```

After Iterators

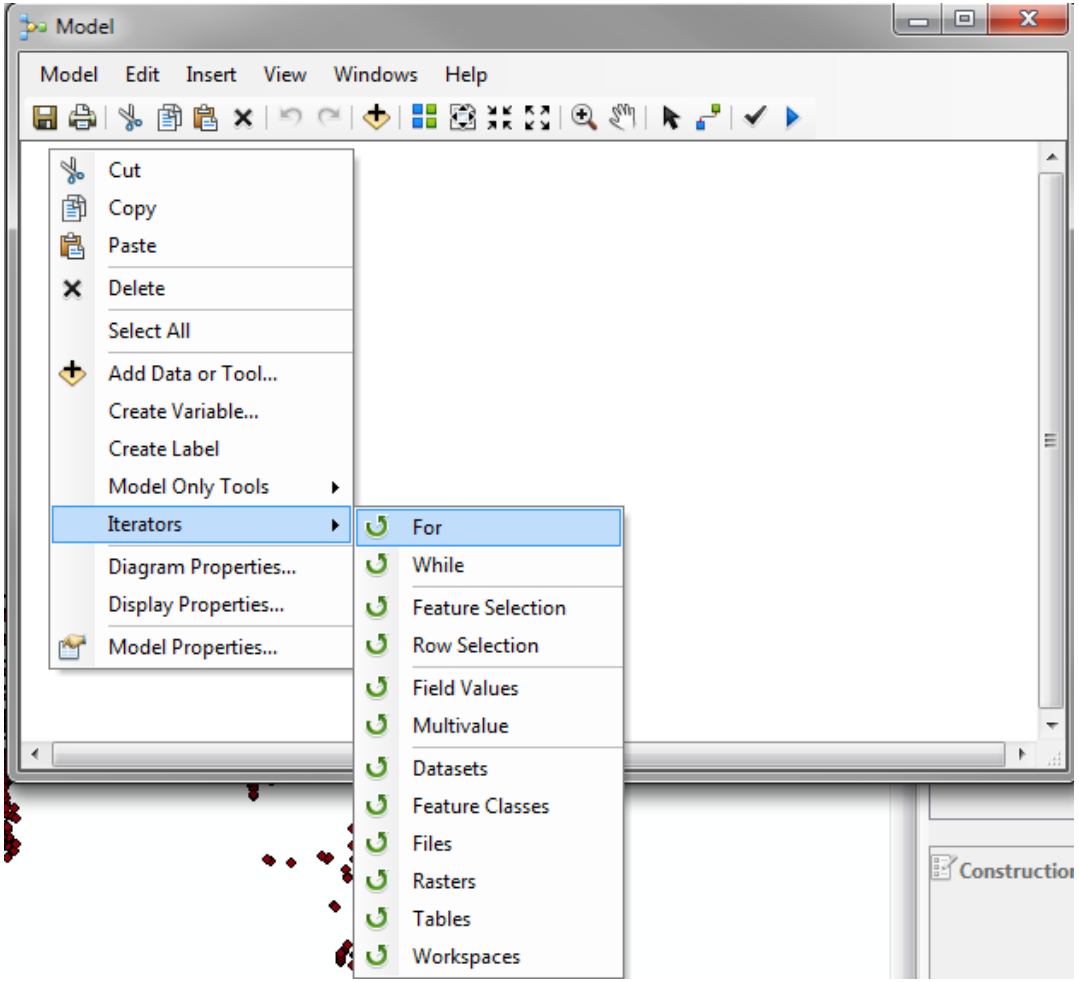


Iterators

They don't export to Python

They can slow down a Model (IMO)

They are easy to use though

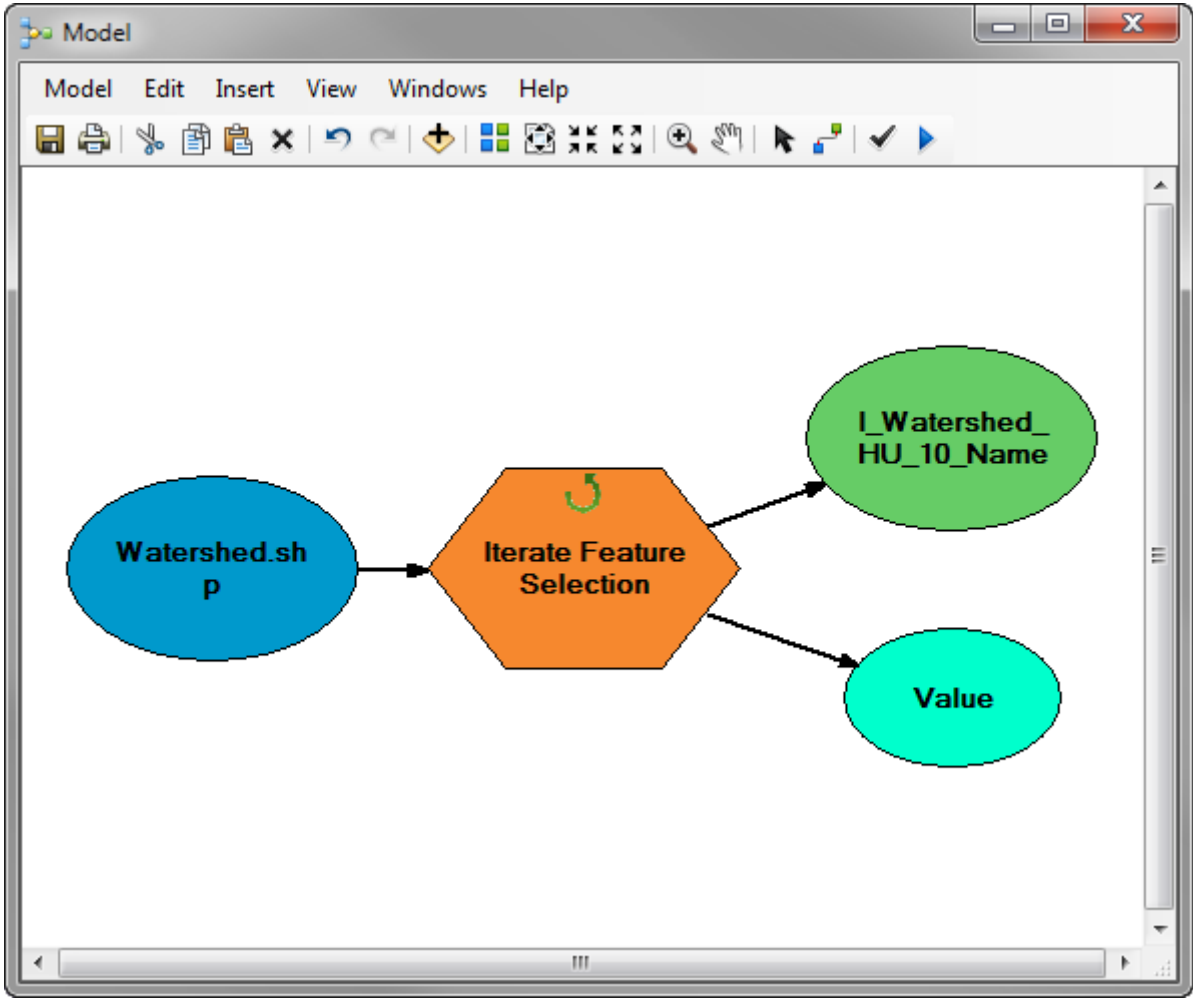


Iterators

Iterator	Description
For	Iterates over a starting and ending value by a given value. It works exactly like `For` in any scripting/programming language, executing through a set number of items.
While	Works exactly like 'while' in any scripting/programming language, executing "while" a condition is true or false for the input or set of inputs.
Iterate Feature Selection	Iterates over features in a feature class.
Iterate Row Selection	Iterates over rows in a table.
Iterate Field Values	Iterates over each value in a field.
Iterate Multivalue	Iterates over a list of values.
Iterate Datasets	Iterates over datasets in a Workspace or Feature Dataset.
Iterate Feature Classes	Iterates over feature classes in a Workspace or Feature Dataset.
Iterate Files	Iterates over files in a folder.
Iterate Rasters	Iterates over rasters in a Workspace or a Raster Catalog.
Iterate Tables	Iterates over tables in a workspace.
Iterate Workspaces	Iterates over workspaces in a folder.

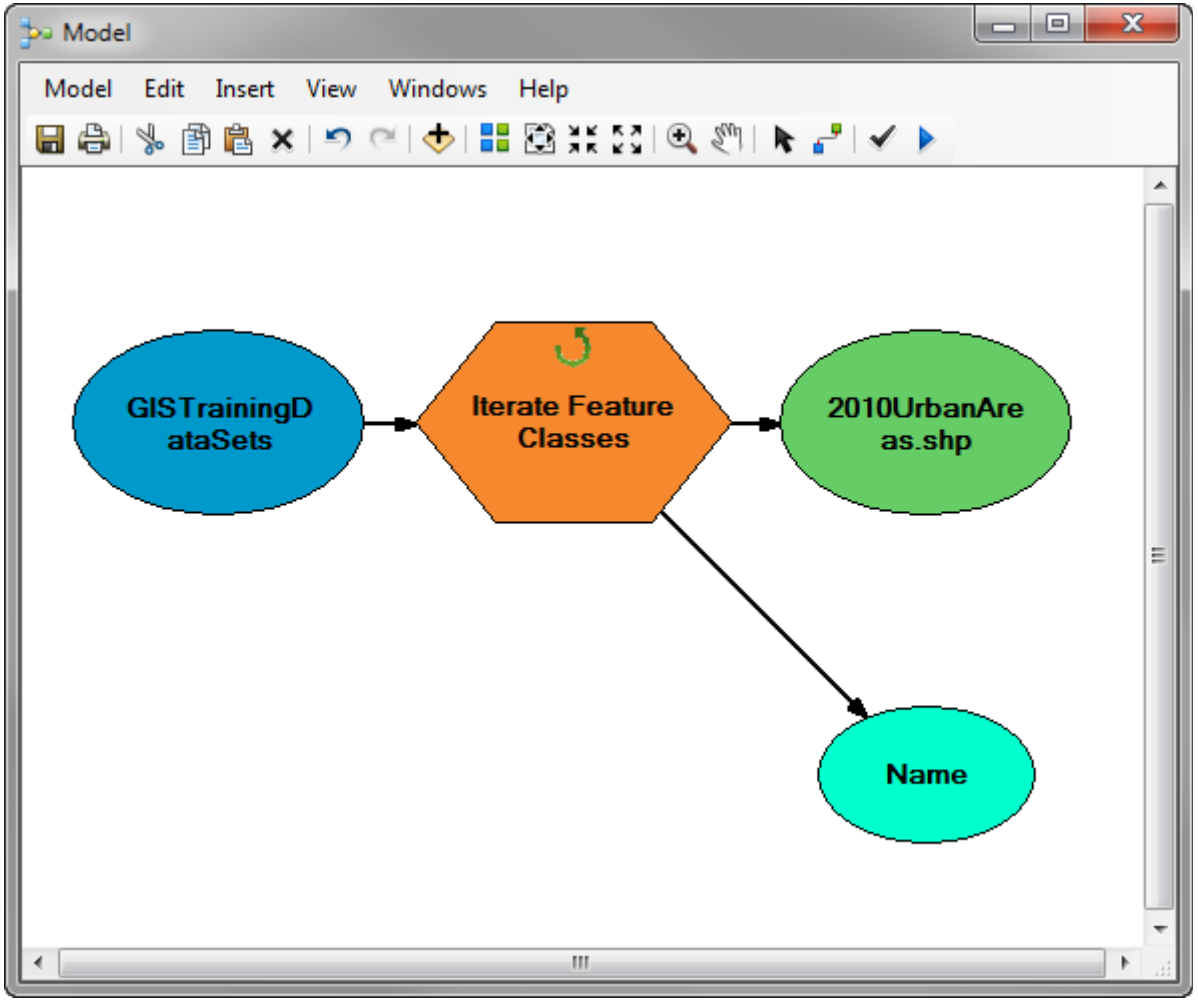
Review the online help:

Feature Selection Iterator



Feature Selection Iterator loops through each feature in a feature class.

Iterate Feature Class

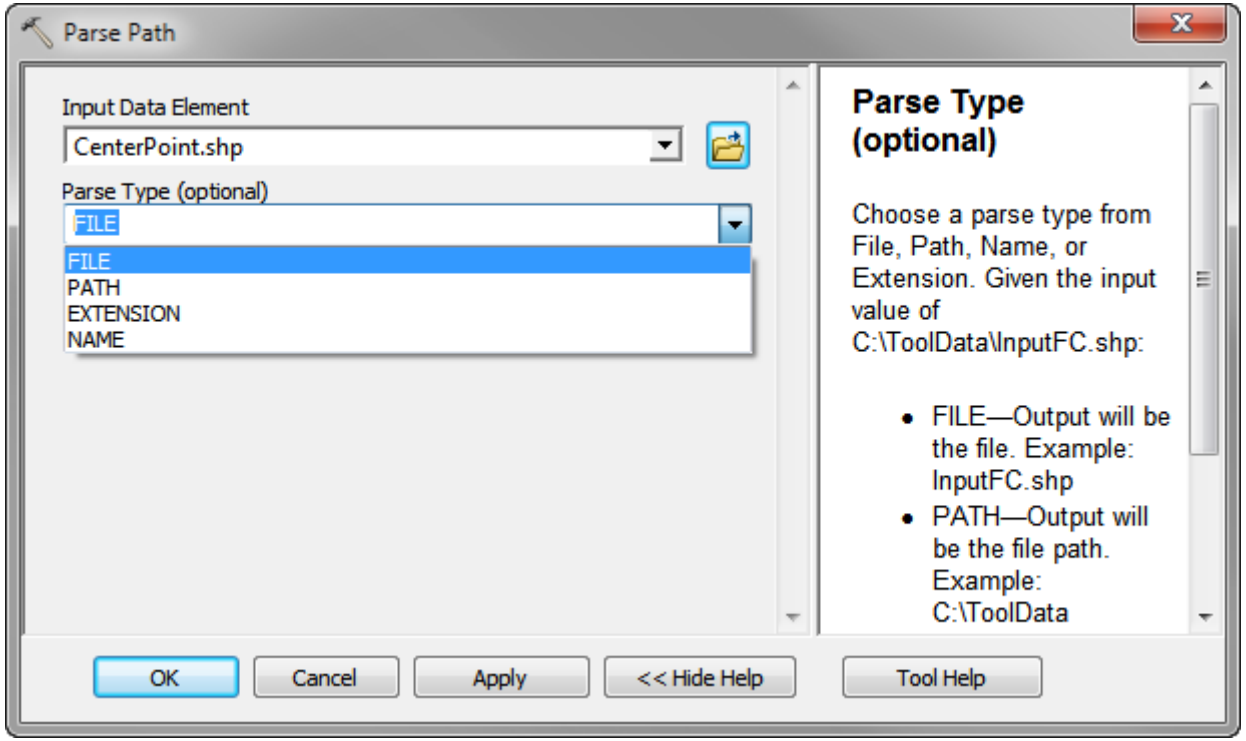


The Feature Class Iterator loops through all the feature classes in a directory or geodatabase.

Model Only Tools

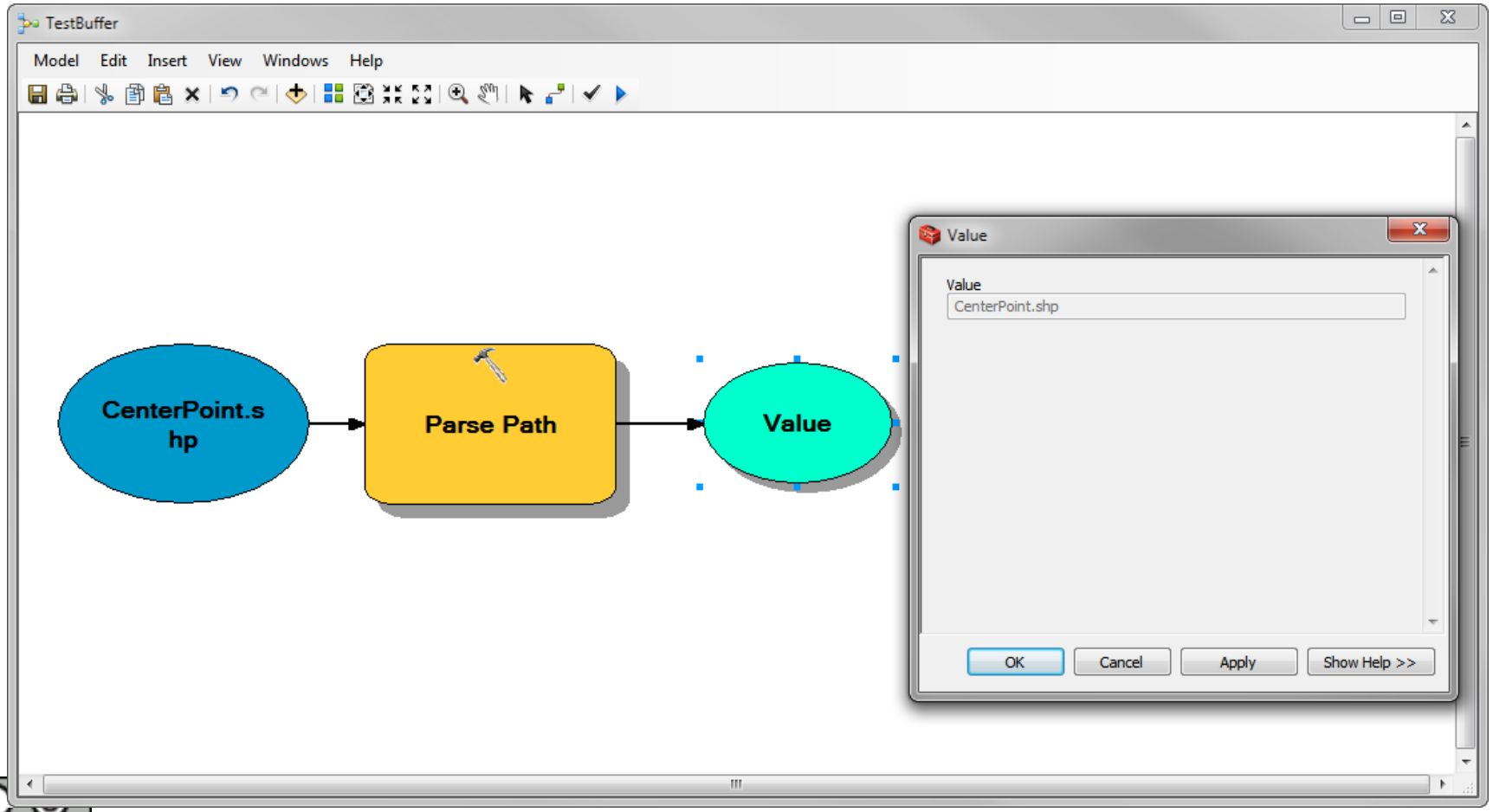
Model Only Tool	Description
Calculate Value	Calculate Value tool returns a value based on a specified Python expression.
Collect Values	The Collect Values tool is designed to collect output values of an iterator, or to convert a list of multivalues into a single input. The output of Collect Values can be used as input to tools like Merge, Append, Mosaic, and Cell Statistics.
Get Field Value	The Get Field Value tool gets the value of the first row of a table for the specified field.
Merge Branch	The Merge Branch tool merges two or more logical branches into a single output.
Parse Path	The Parse Path tool parses the input into its file, path, name, or extension. The output can be used as in-line variables in the output name of other tools.
Select Data	The Select Data tool selects data in a parent data element such as a folder, geodatabase, feature dataset, or coverage.
Stop	For the set of input values, iteration will stop if all the input values meet the specified conditon of either True or False. It is functionally similar to While iterator but is useful to stop a model if there is one While iterator in a model and no additional iterators can be added.

Example of Parse Path



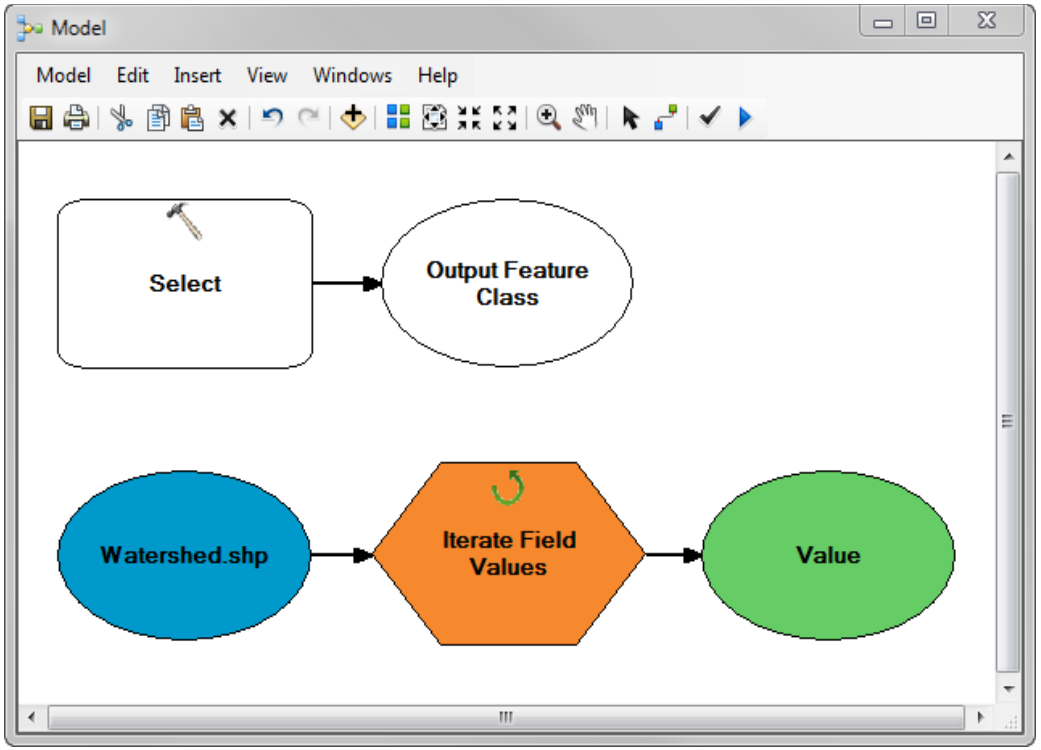
Parse Path

- Path was remove from filename



Exercise 6

- Work with Iterators in ModelBuilder
- Work with Model Only Tools
- 20 Minutes

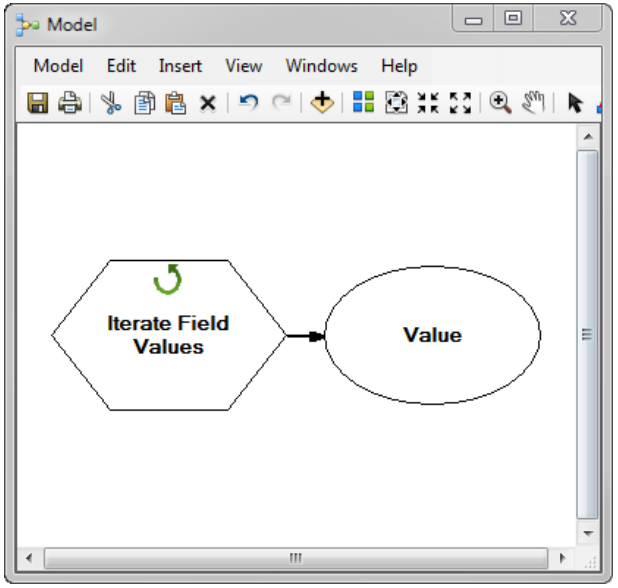


Exercise

1. Open your MXD from the previous exercise if you closed it.

2. Open a **New Model** by clicking on the Model Builder Icon in ArcMap.

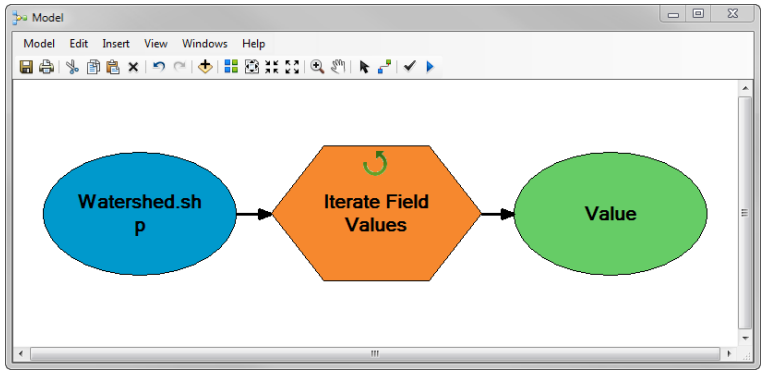
3. Add the **Iterate Field Values** Iterator to the Model Right-click and select it from the Iterator menu.



4. Open the Iterate Tool. For the input table select the Watershed.shp.

6. For the field select the **Hu_10_name** field.

7. Click OK.

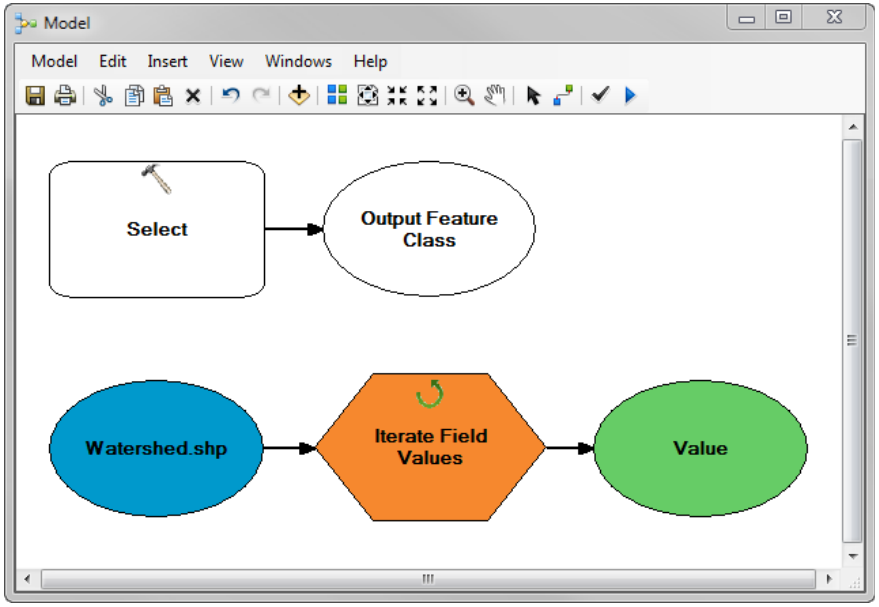


Exercise

8. **Search** and add the **Select** (analysis) tool.

9. Double-click the Select tool and add **Watershed.shp** as the **Input Feature**.

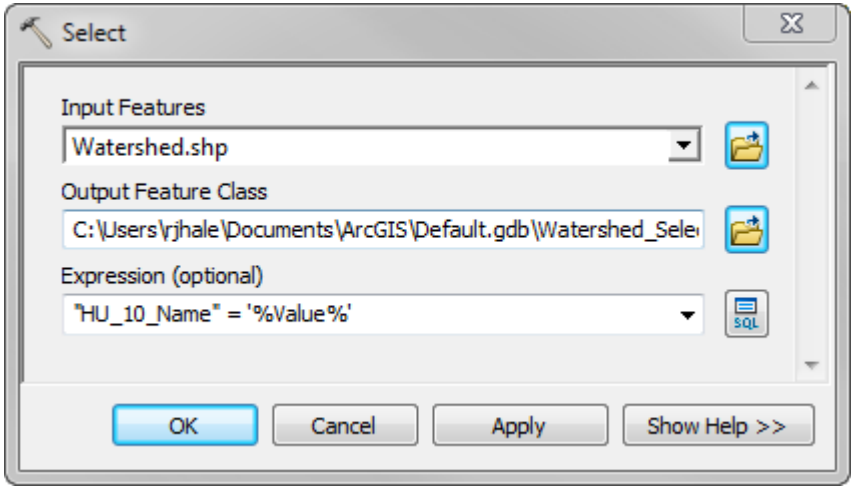
10. Make the output c:\modelbuilder**%Value %.shp** . The Iterate tool outputs a variable with the value of the **Hu_10_name** field.



11. Make the Expression be the following: **"HU_10_Name" = '%Value%'**

12. Run the Tool

13. Save it and give it a name.

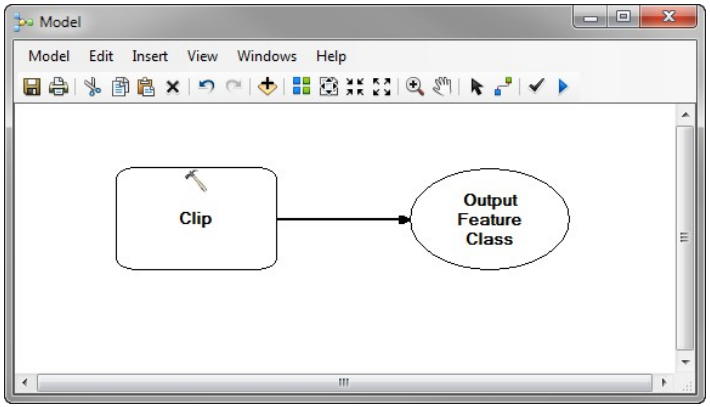


Exercise

Bonus:
Take each feature in the Watershed shapefile and use it to clip out the streams.

Introduction to Model Builder and Python

Chapter 7: Python & ArcPy



7. Python and ArcPy

Python is a remarkably powerful dynamic programming language that is used in a wide variety of application domains. Python is often compared to Tcl, Perl, Ruby, Scheme or Java. Some of its key distinguishing features include:

- very clear, readable syntax
- strong introspection capabilities
- intuitive object orientation
- natural expression of procedural code
- full modularity, supporting hierarchical packages
- exception-based error handling
- very high level dynamic data types
- extensive standard libraries and third party modules for virtually every task
- embeddable within applications as a scripting interface

GIS

GIS software is currently having a love affair with Python

Open Source:

QGIS, PostGIS, OSGeo, GDAL, gispython.org

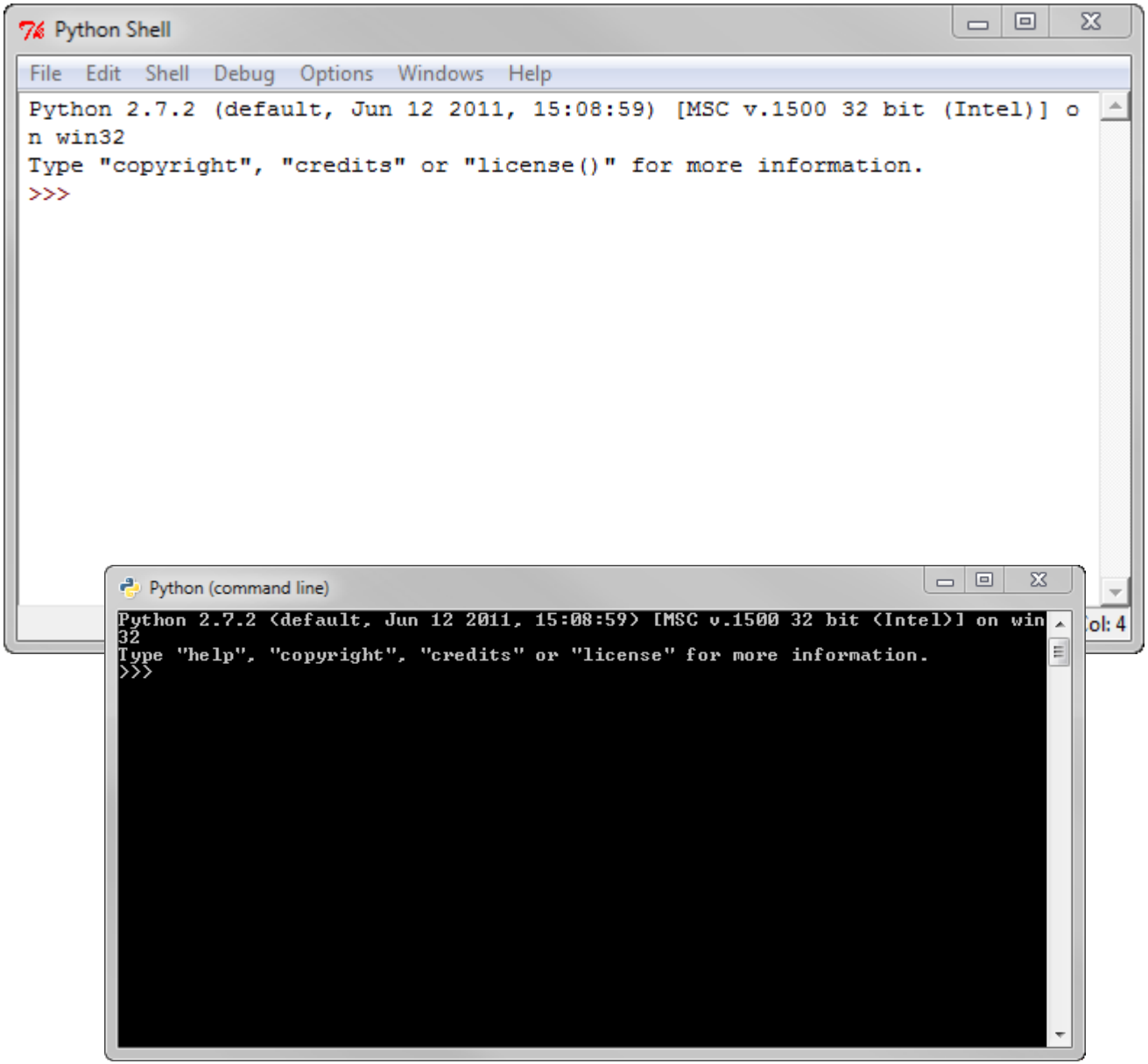
Closed Source:

ArcGIS is probably the biggest

Install of ArcGIS

Python 2.7
- IDLE
- PythonWin

For editing I prefer notepad or VIM



Features of Python

- Control Flow
  If, For, Else, While

  Declare Variables

  Work with Integers

  Capture Errors

  Build modules to import that do specific things
  ARCPY is the one you will be most concerned with

Resource Sites

http://www.python.org

http://www.codeacademy.com

http://www.swaroopch.com

http://www.oreilly.com

ArcGIS Help Documentation

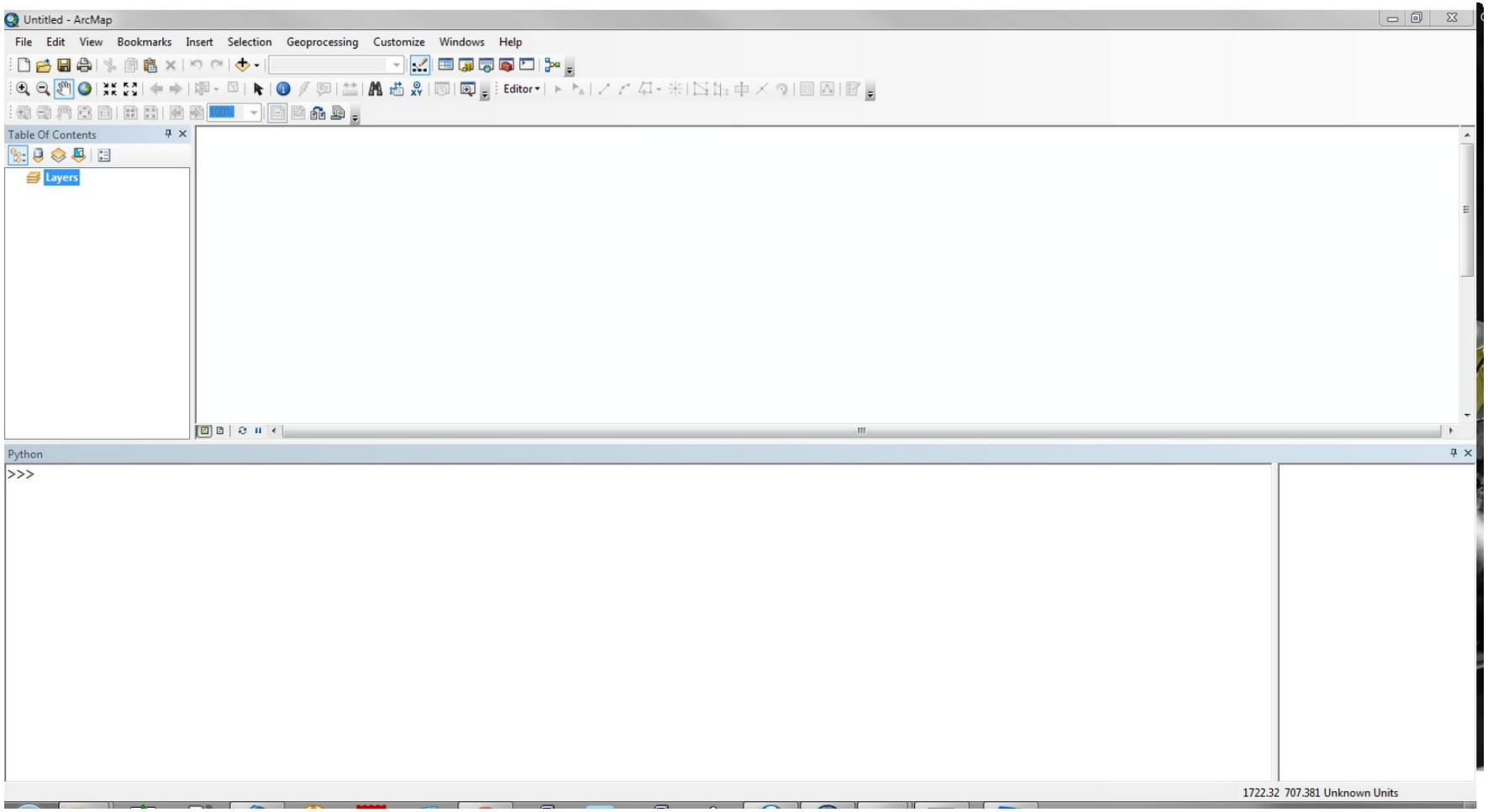
ArcPy

ArcPy is a site package that builds on (and is a successor to) the successful arcgisscripting module. Its goal is to create the cornerstone for a useful and productive way to perform geographic data analysis, data conversion, data management, and map automation with Python.

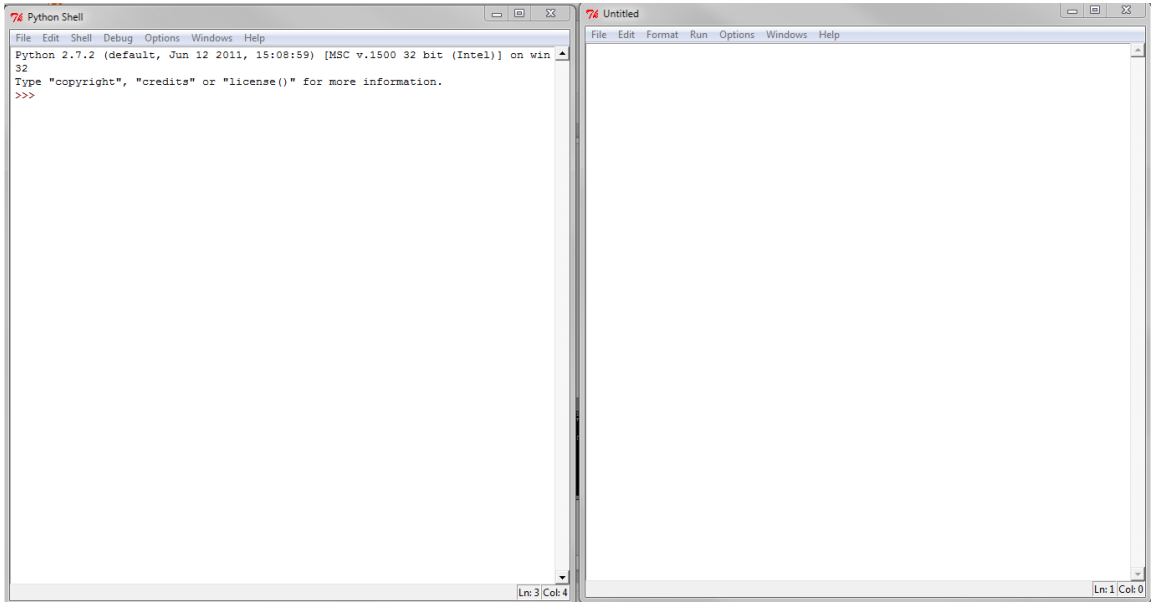
ArcPy provides access to geoprocessing tools as well as additional functions, classes, and modules that allow you to create simple or complex workflows quickly and easily.

#import arcpy;

Interface(s)

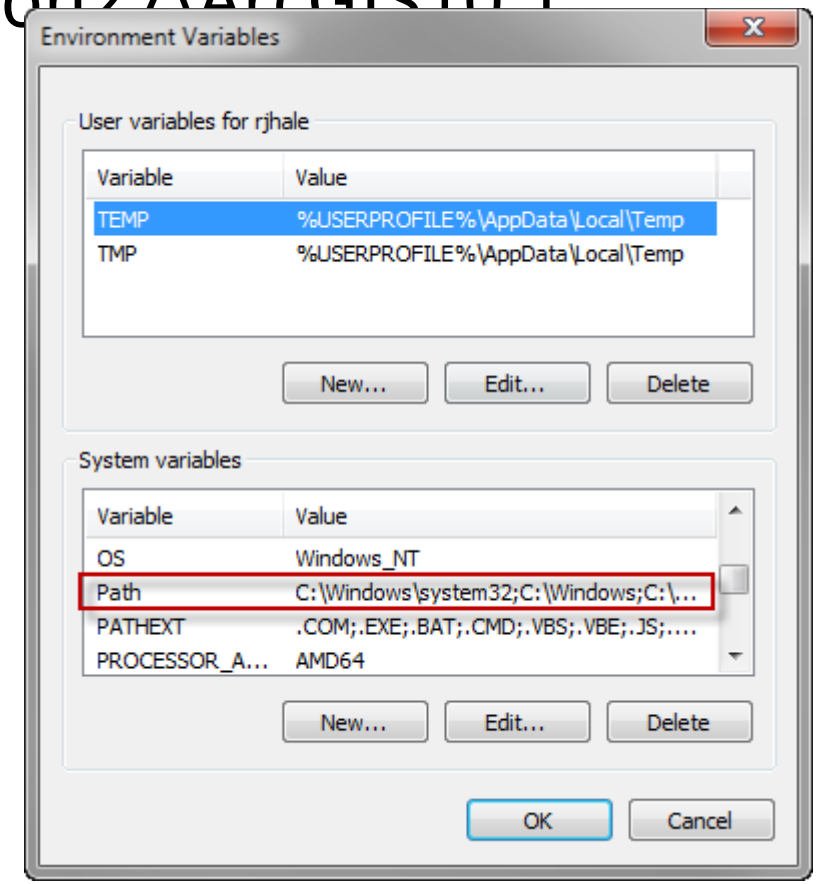


Interface(s)



So for ArcUsers.....

- Add Python to your path statement
  Found under Environment Variables
  Add: C:\Python27\ArcGIS10.1



Example of a for Statement

```
import arcpy
from arcpy import env
import os

# Set the workspace for the ListFeatureClass function
#
env.workspace = "c:\Data"

# Use the ListFeatureClasses function to return a list of
#  all shapefiles.
#
fcList = arcpy.ListFeatureClasses()

# Prints list of shapefiles in workspace to screen
#
for fc in fcList:
    print fc
```

Variable Example

Variables can be text or numeric

Scripts can accept inputs

- InputTable = arcpy.GetParameterAsText(0)
- Census = arcpy.GetParameterAsText(1)

If you build a script and want to pass data into it, you would use: arcpy.GetParameterAsText()

ArcPy

As with Model Builder - Know your Geoprocessing Tools

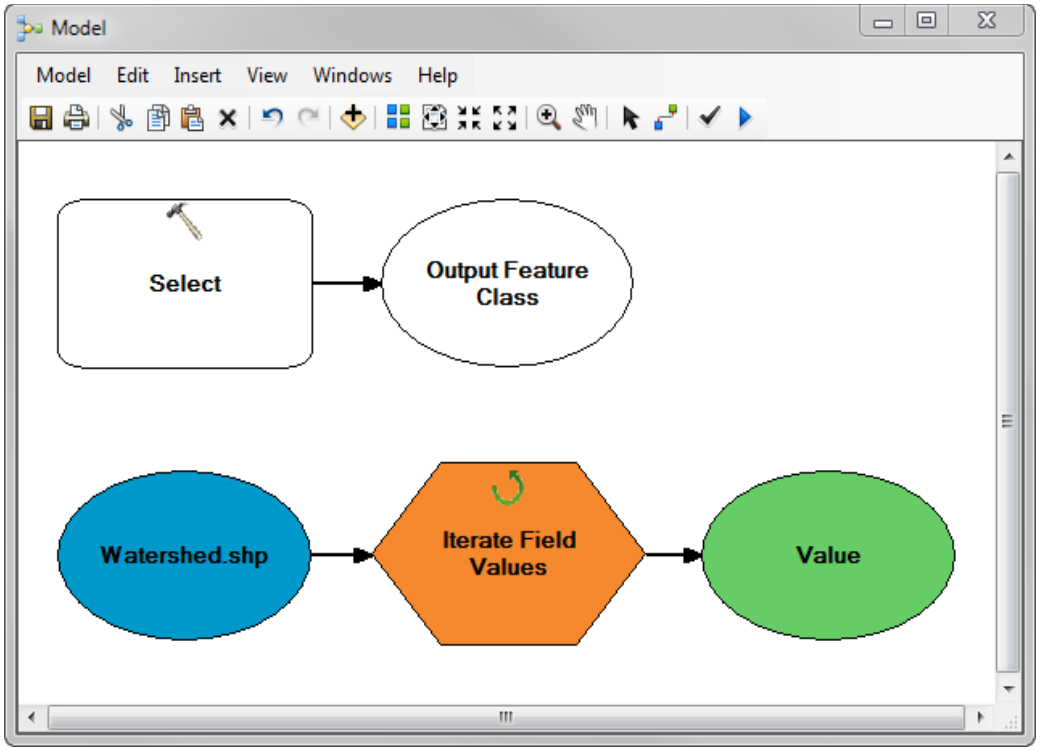
You do not have to be an expert programmer to get something done in a script

Make mistakes

I have made hundreds and will continue making hundreds more

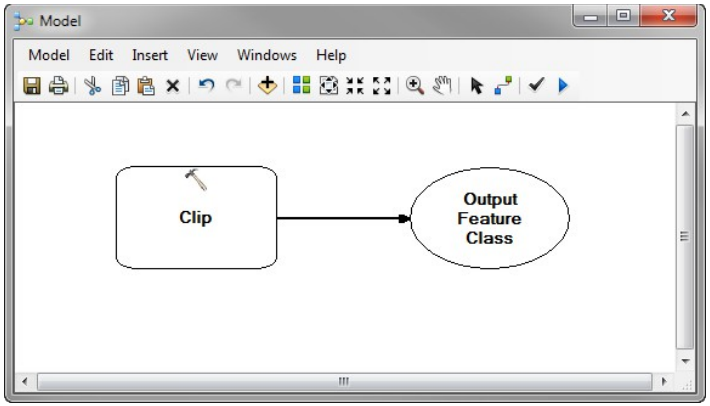
Exercise 7

- No exercise
- Break



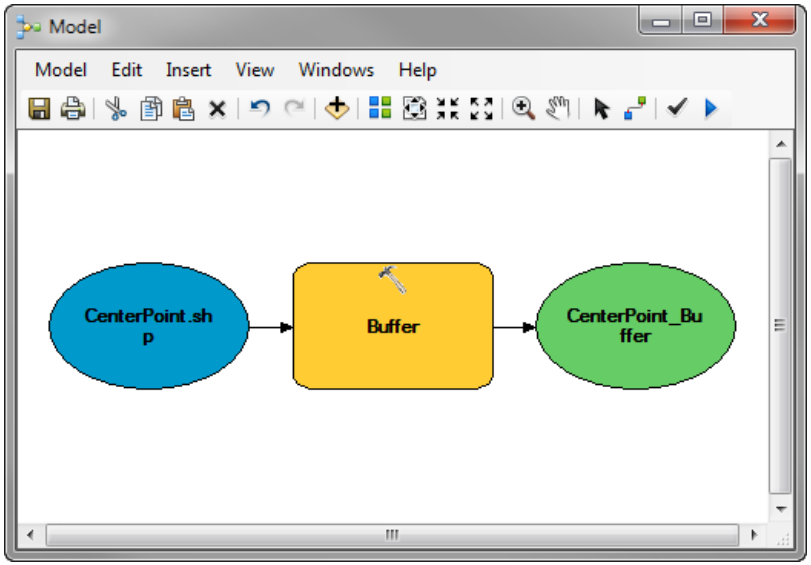
Introduction to Model Builder and Python

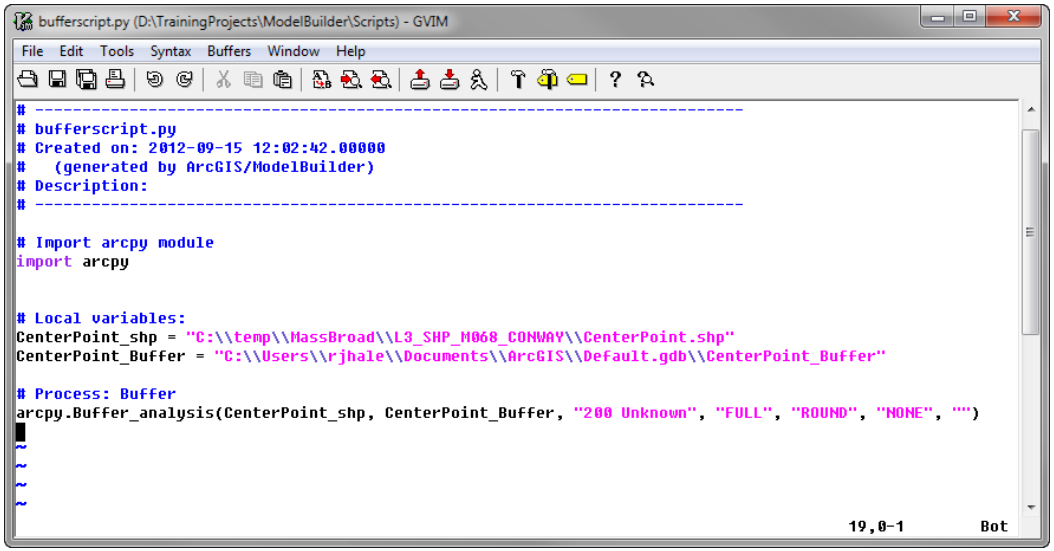
Chapter 8: Exporting a Model to Python



8. Exporting Model to Python

- Model Builder can export to Python
- Iterators can't be exported
- Model Only Tools can't be exported

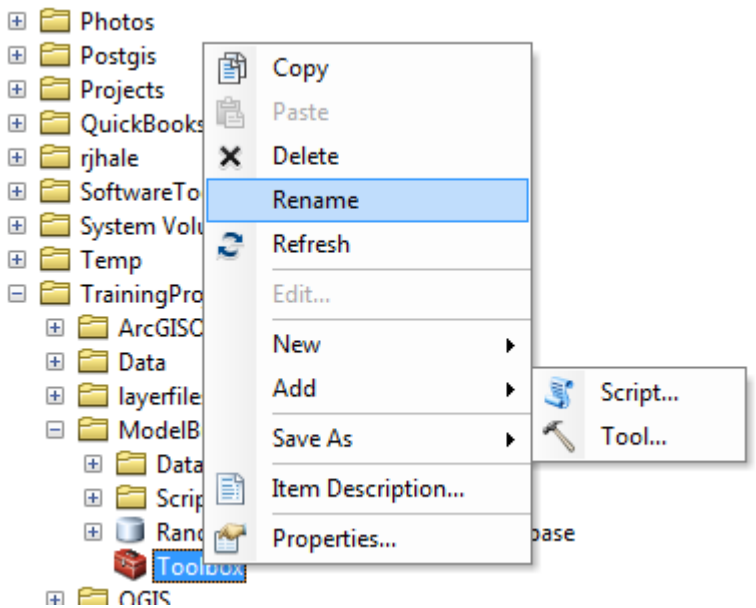




Once Exported

- Script can be customized to fit your need
- Can be re-imported into model Builder
- Can be run from Python window in ArcMap

Add script back to ArcToolbox



If you write a script look at the variable

You can make an input and output

Will appear that way in Model Builder

Tips

- Simpler the better
- Don't get too fancy
- Make lots of notes
  #because notes are important
- Nothing works right the first time
- It might not work right the second time

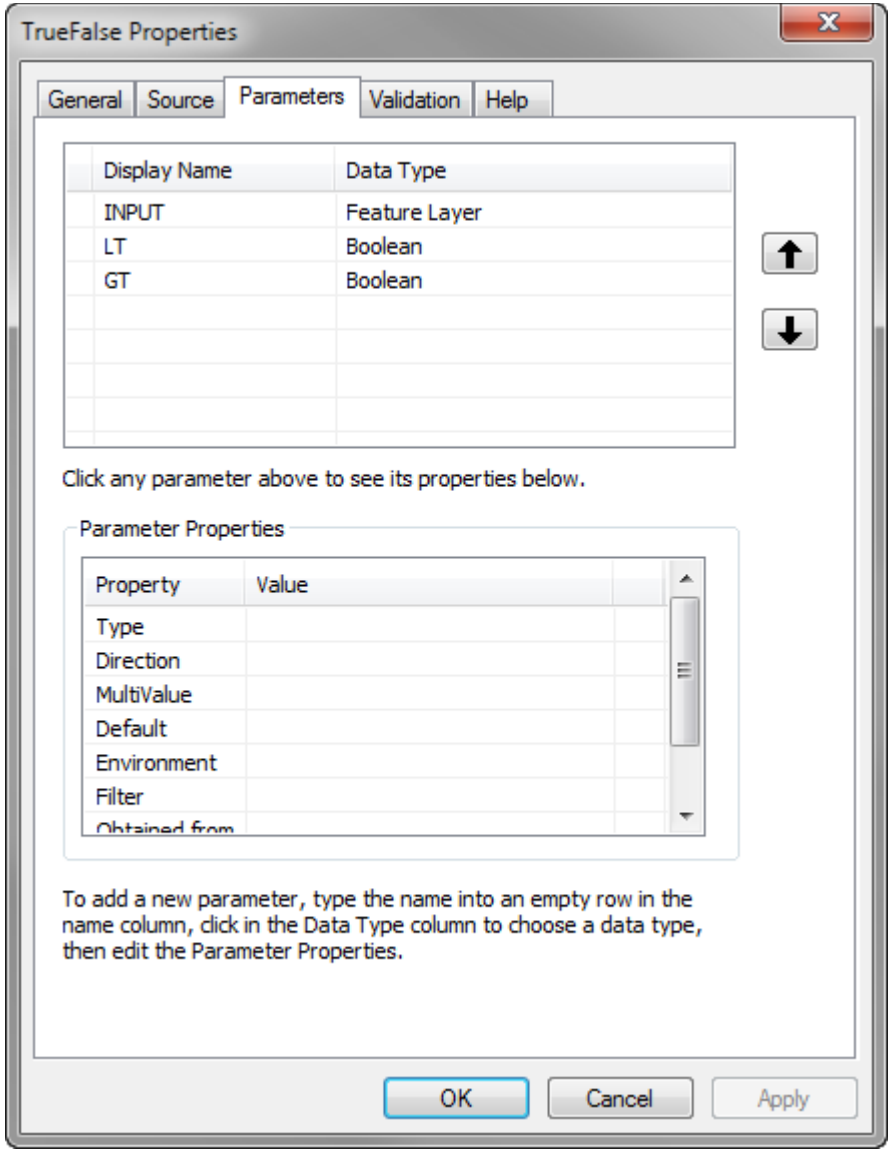
Example of True/False

TrueFalseTest.py - Notepad

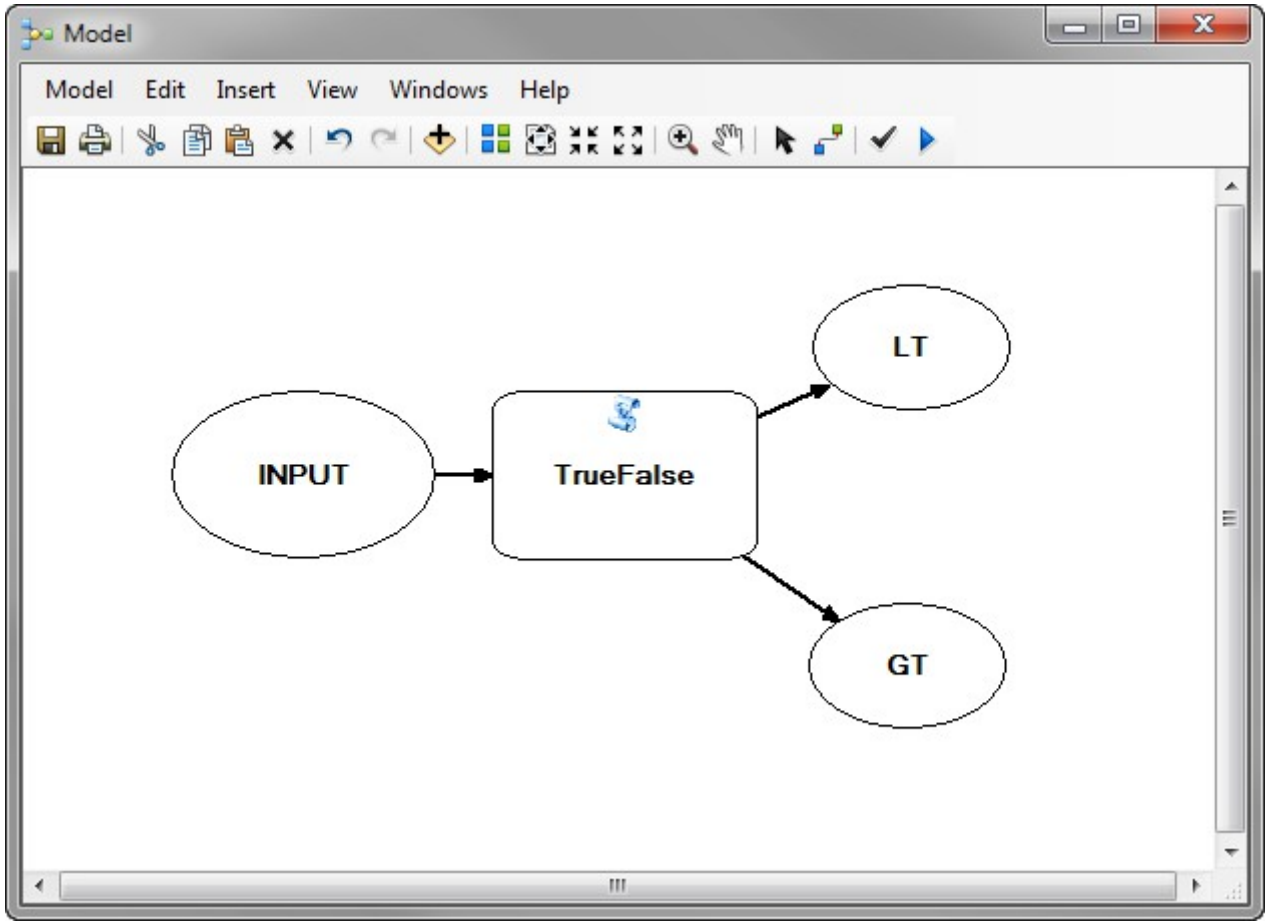
File Edit Format View Help

```
# Import modules
import arcpy
import sys
import traceback


# Set local variables
data = 0
indata = arcpy.GetParameterAsText(0)
arcpy.AddMessage(indata)

try:

   data = int(str(arcpy.GetCount_management(indata)))
   arcpy.AddMessage("****************")
   arcpy.AddMessage(data)
   arcpy.AddMessage("****************")

   if data <= 2:
   #Param1 is LT: Param2 is GT
   #Set appropriately to control the flow
      arcpy.SetParameterAsText(1,"true") #LT
      arcpy.SetParameterAsText(2,"false") #GT
      arcpy.AddMessage("****************")
      arcpy.AddMessage("*Less than 2.....")
      arcpy.AddMessage("****************")
      del data


   else:
      arcpy.SetParameterAsText(1,"false") #LT
      arcpy.SetParameterAsText(2,"true") #GT
      arcpy.AddMessage("****************")
      arcpy.AddMessage("*Greater than 2......")
      arcpy.AddMessage("****************")
      del data


except:
   tb = sys.exc_info()[2]
   tbinfo = traceback.format_tb(tb)[0]
   pymsg = tbinfo + "\n" + str(sys.exc_type)+ ": " + str(sys.exc_value)
   arcpy.AddError("Python Messages: " + pymsg + " GP Messages: " + arcpy.GetMessages(2))
```

Added to ArcToolbox

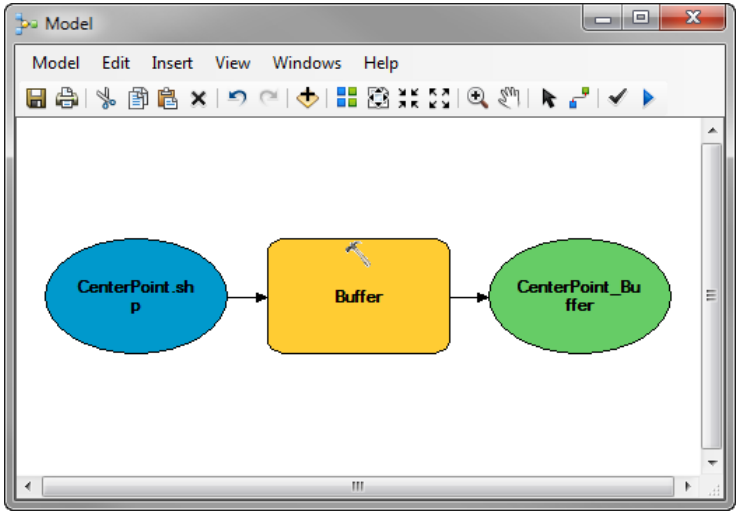


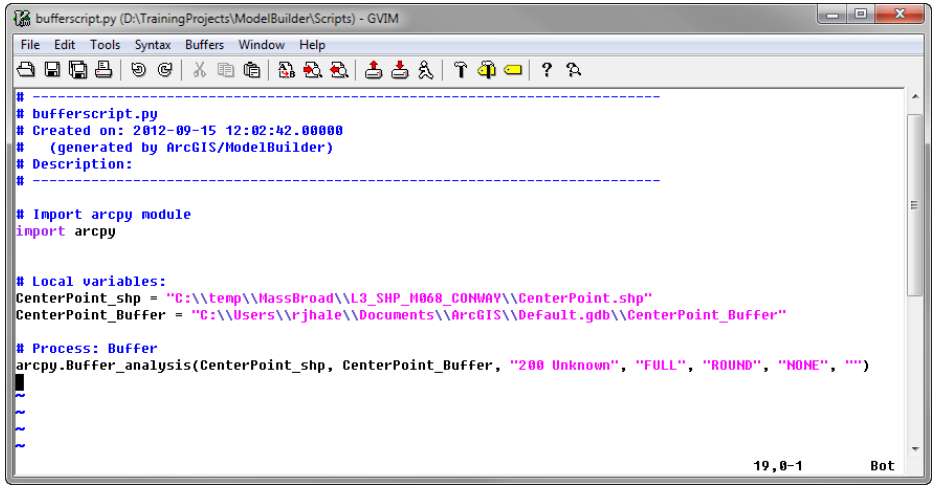
Added To Model Builder



Exercise 8

- Export a model to python
- Load a Python Script into Python Window
- 20 Minutes



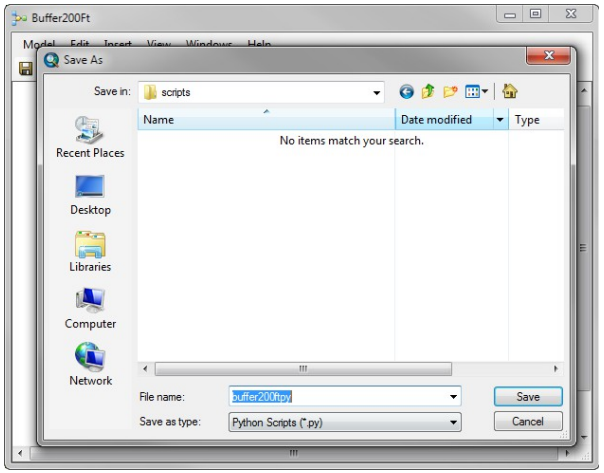


Exercise

1. Open your MXD from the previous exercise if you closed it.

2. Open the **Buffer200Ft Model**.

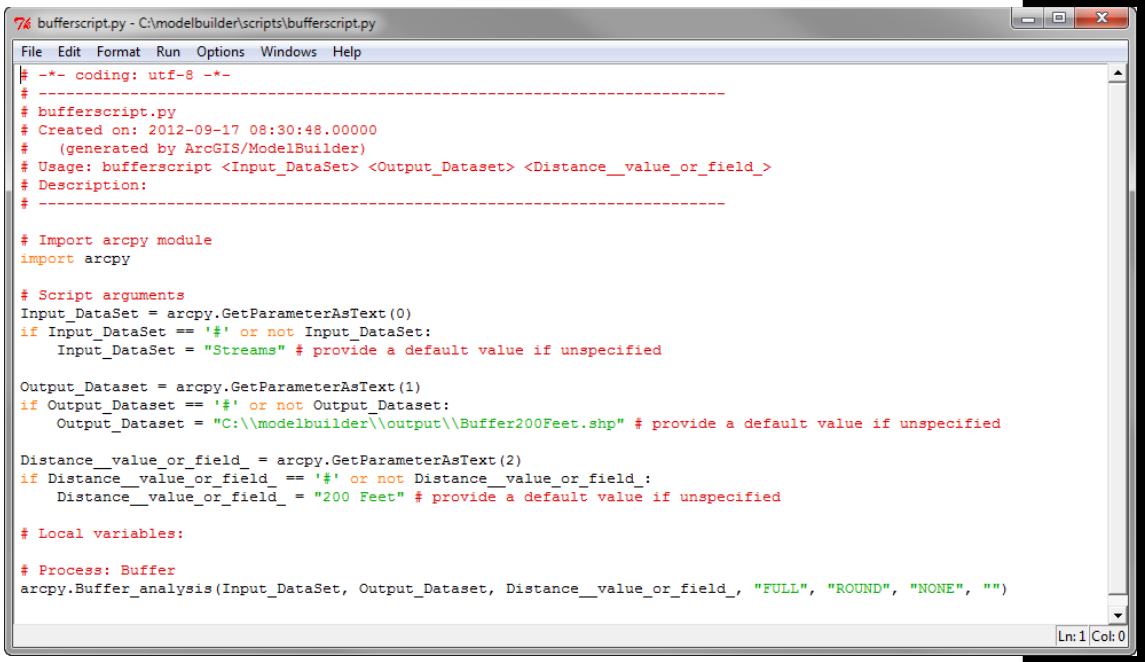
3. Go to **Model -> Export -> To Python Script**.



4. Right-click the script in Windows Explorer and **Edit** it with **IDLE**.

6. Take a look at the script that is created from Model Builder.

7. If you want create a very simple Model and export it to Python and see what it looks like.



Exercise

8. In ArcMap , open your Python console.

9. Look back at **IDLE** and look at the **arcpy.Buffer_analysis** command.

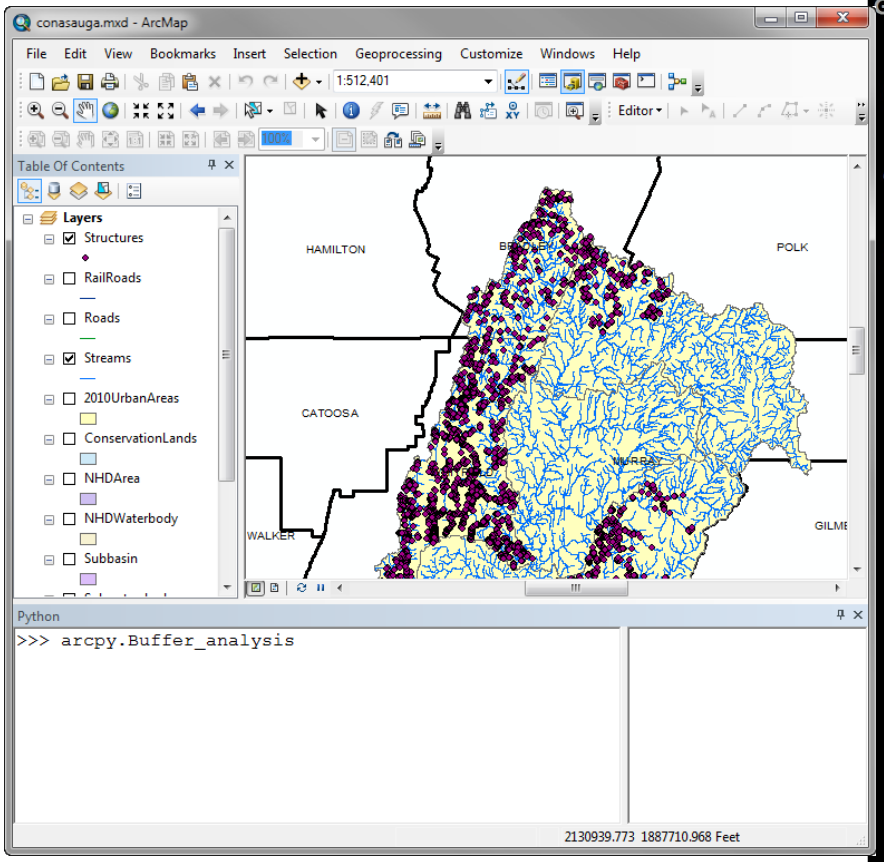
10. What happens?

11. Finish out the command. It should look something like:

arcpy.Buffer_analysis("Streams", "C:\modelbuilder\data\streamstest.shp", 200, "FULL", "ROUND", "ALL")

12. Right-click in the Python console and select Save as and save that to a Python script.

13. Take a look at the script.



Exercise

14. Right-click in your Python console and click **Load**

15. Load the **Buffer** script that you exported from Model Builder earlier.

16. Press **Return** in the Python window. What happens?

17. Open Your Python Console.

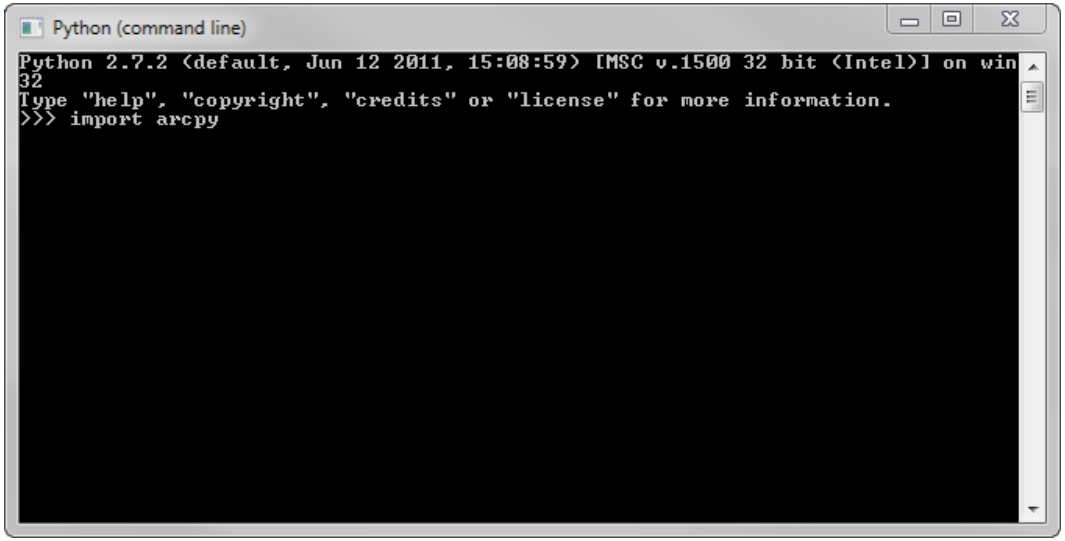
18. Type: import arcpy

19: Copy your **Buffer** command from your saved script (see below) into the window.

arcpy.Buffer_analysis("Streams", "C:\modelbuilder\data\streamstest.shp", 200, "FULL", "ROUND", "ALL")

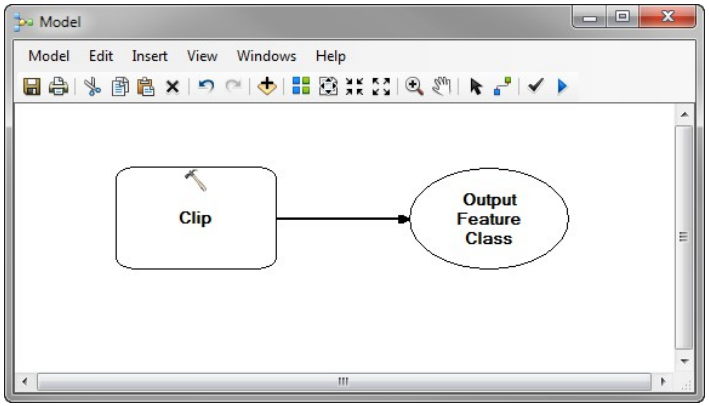
20. Press **Return**.

21. What happens?



Introduction to Model Builder and Python

Chapter 9: Documenting your work



python

9. Writing Help

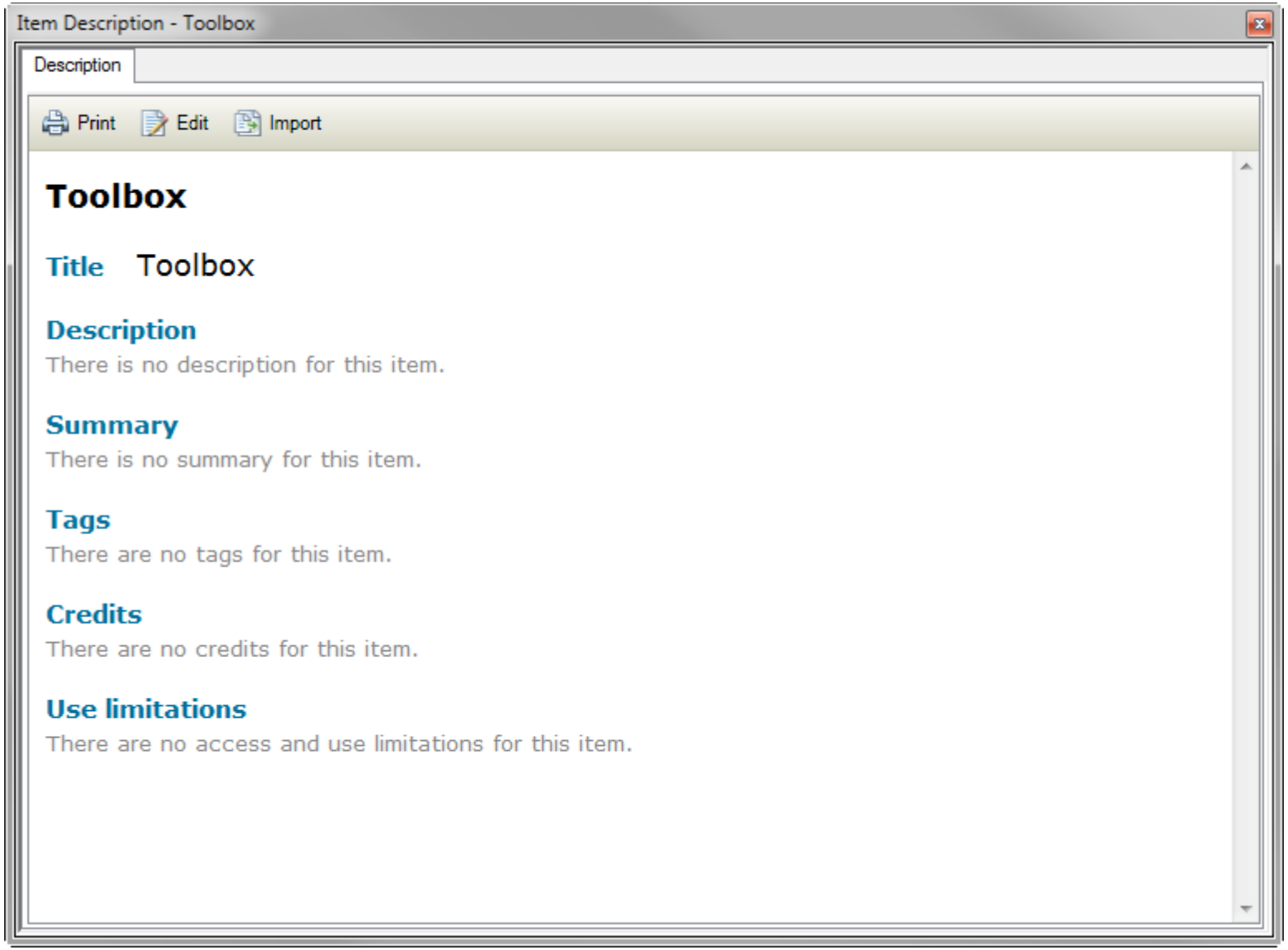
- You've done all this work

DOCUMENT IT

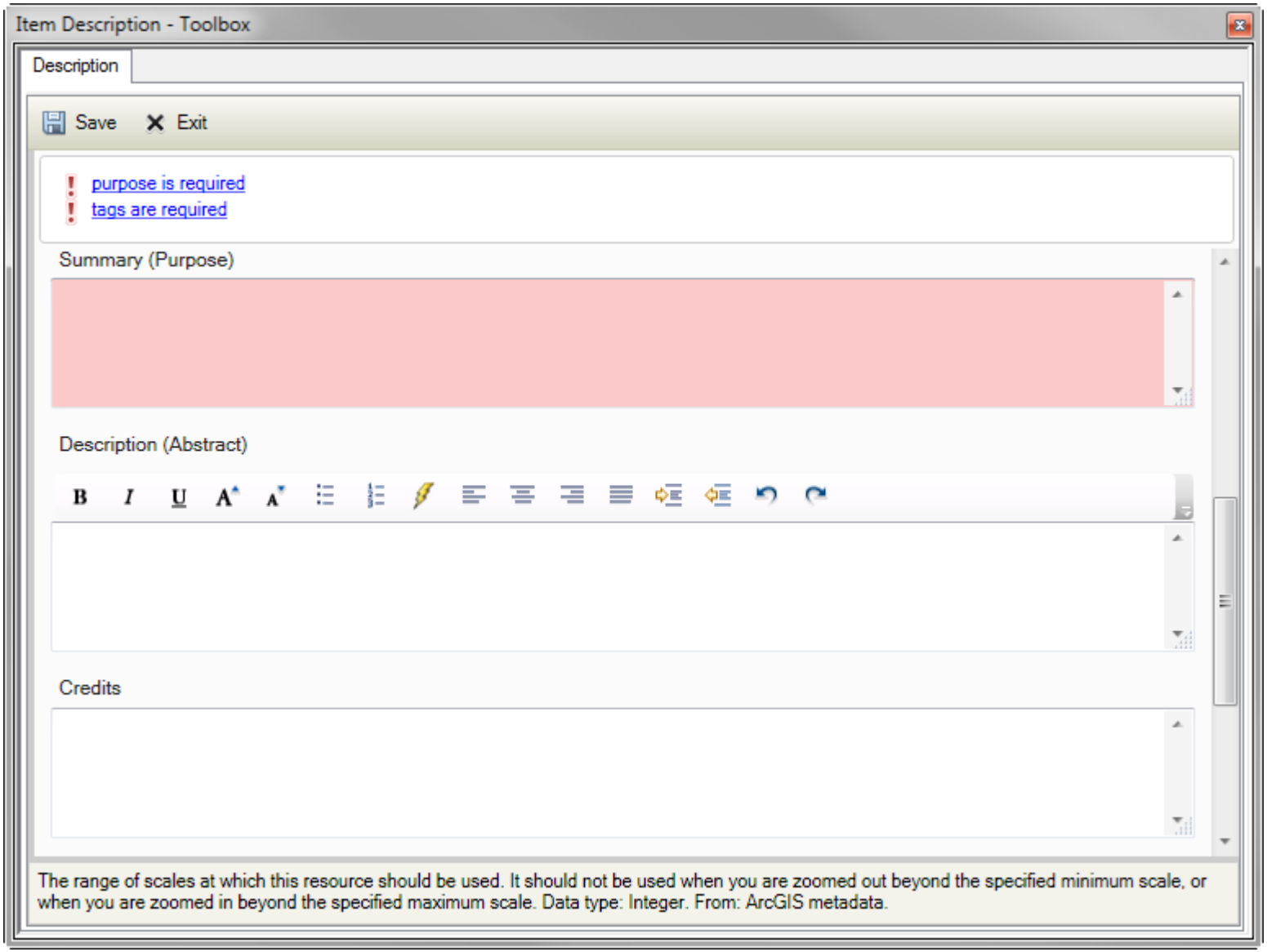
Item description

- Right-click the Model in ArcToolbox or ArcCatalog
- Go To Item Description
- Think about why you created this Model/Script and who can use it.
- Edit the description

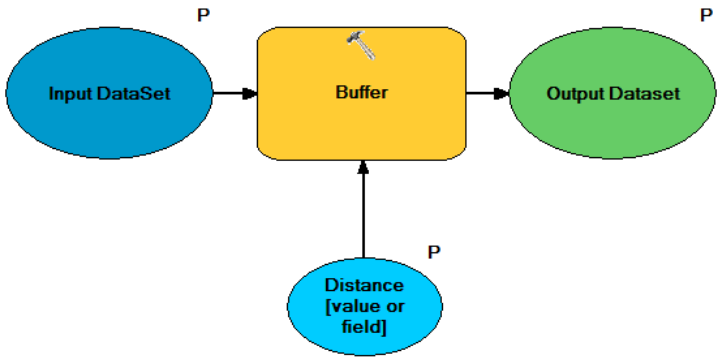
Item Description



Item Description Edited



Exercise



1. Open your MXD from the previous exercise if you closed it.

2. Open the **Buffer200Ft Model**

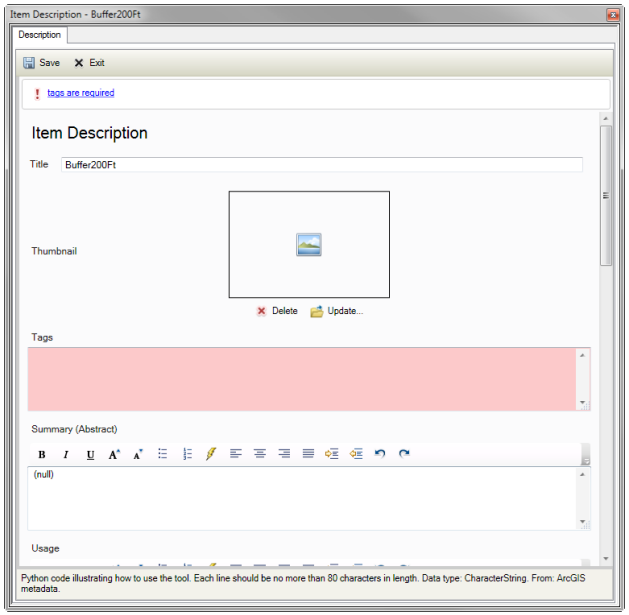
3. Go to **Model -> Export -> To Graphic**. Make the file type jpg.

4. Right-click the Model in ArcCatalog and go to **Item Description**.

6. Click **Edit**.

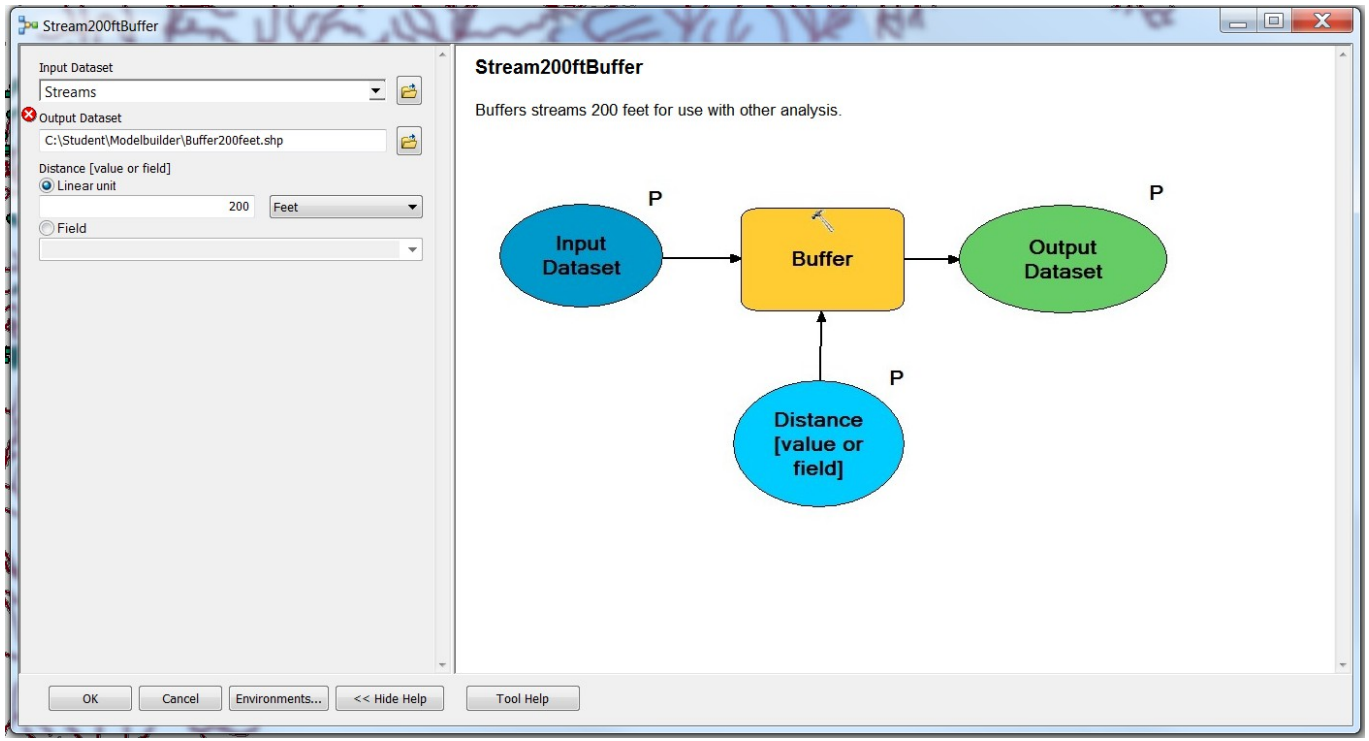
7. Add the exported Graphic.

8. What are tags and why are they important?



Exercise 9

- Create metadata for your model
- Show how it helps when running it
- 20 Minutes



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http://www.northrivergeographic.com

Miso. 3.5 lbs of happy.

If you got this far in the class
you should go and donate some
Resources to your local human/animal
shelter.