Brigham Young University
BYU ScholarsArchive

Engineering Applications of GIS - Laboratory Exercises

Civil and Environmental Engineering

2017

Laboratory X - Autonomous Vehicle Application

Nate Lant

Matthew Strong

Follow this and additional works at: https://scholarsarchive.byu.edu/gislabs

Part of the Civil Engineering Commons, and the Geographic Information Sciences Commons

Recommended Citation

Lant, Nate and Strong, Matthew, "Laboratory X - Autonomous Vehicle Application" (2017). *Engineering Applications of GIS - Laboratory Exercises*. 4.
https://scholarsarchive.byu.edu/gislabs/4

This Article is brought to you for free and open access by the Civil and Environmental Engineering at BYU ScholarsArchive. It has been accepted for inclusion in Engineering Applications of GIS - Laboratory Exercises by an authorized administrator of BYU ScholarsArchive. For more information, please contact scholarsarchive@byu.edu, ellen_amatangelo@byu.edu.

Matt Strong
Nate Lant
CEEn 414 – Final Project
December 13, 2017

Laboratory X - Autonomous Vehicle Application

Background

Autonomous vehicles are currently the newest and hottest technology and show tremendous potential in making current transportation much more efficient. GIS is a key element in providing different mapping solutions and satellite assistance to support the cars in addition to their LIDAR and camera systems.

Over the last few decades, different technologies have been integrated into cars to make them more user friendly--more autonomous. Recently, cars have been given a standardized range to categorize them into different levels of autonomy. The levels range from 0 to 5. Level 0 has no capacity of any autonomous technology; level 1 has cruise control or anti-lock brake system; now, level 5 is completely driverless, meaning, the car does not even need a steering wheel.

Problem Statement

As companies like Tesla, Ford, GM, Nissan, and others continue to produce cutting edge vehicles with more and more autonomous functions, people too quickly become too reliant on the technology. Level 3 autonomy is proving to be extremely dangerous, not because the technology is faulty, but because the human control is too susceptible to trusting the car more than they should. Many studies have looked into ways that a level 3 vehicle can alert the driver to remain “hands-on” during times where the vehicle is no longer capable of driving. These locations and situations need to be identified and programmed into the car.

As LIDAR is a very effective way for the vehicles to communicate with its surroundings and the infrastructure, there are certain elements that can serve as a problem to LIDAR systems. For example, if a vehicle is on a road that has a dramatic change in slope (on the top of a hill or at the bottom) the LIDAR could bounce or refract differently than expected.

Using ArcMap, students are to identify these locations of dramatic slope change on the roads of Salt Lake City. These locations will be used in the programming of level 3 driverless cars to alert the driver to take control at these areas.

Spatial Considerations

For the purposes of this exercise, you will be locating parts of the roads in Salt Lake City that are not suitable for LIDAR systems to run automatically. You will find curvature less than -1.0 and greater than 1.0 and slopes greater than 9 degrees.

Data

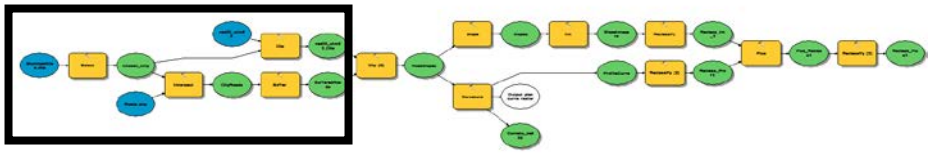
- http://gis.utah.gov/data/sgid-transportation/roads-system/ UDOT Roads: you can find a shapefile that represents all the mahor roads and highways in Utah. You will download the Road Centerlines: Shapefile
- https://gis.utah.gov/data/boundaries/citycountystate/ City Data (municipalities): you can find a shapefile that represents all of the municpalities in Utah. You will need to download the Municipal Boundaries: Shapefile
- http://gis.utah.gov/data/elevation-terrain-data/10-30-meter-elevation-models-usgs-ned/ NED data: you will need to download the Statewide 30 meter DEM (975MB) to have a DEM of the whole state.

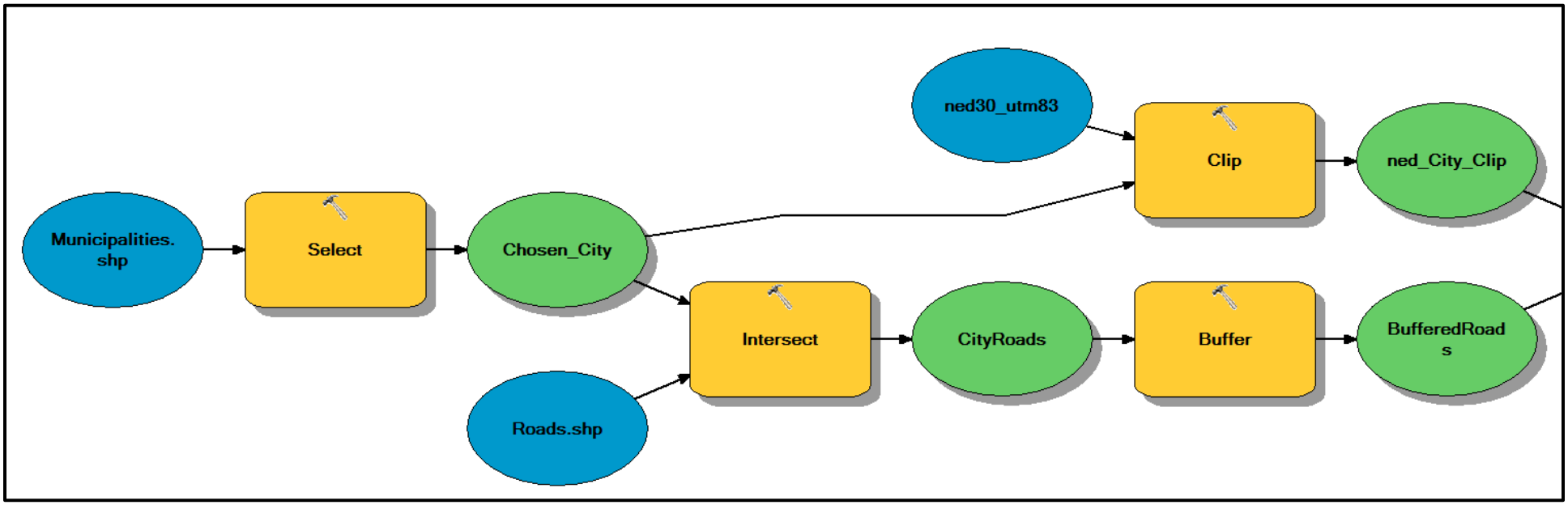
ModelBuilder Tools

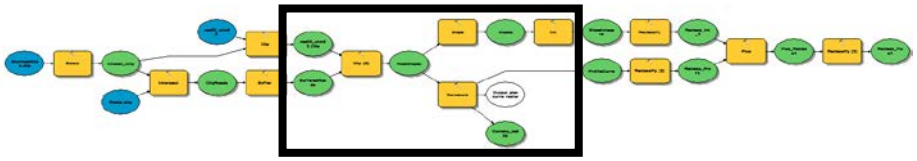
In this exercise you may use previous tools and will us the following new tools.

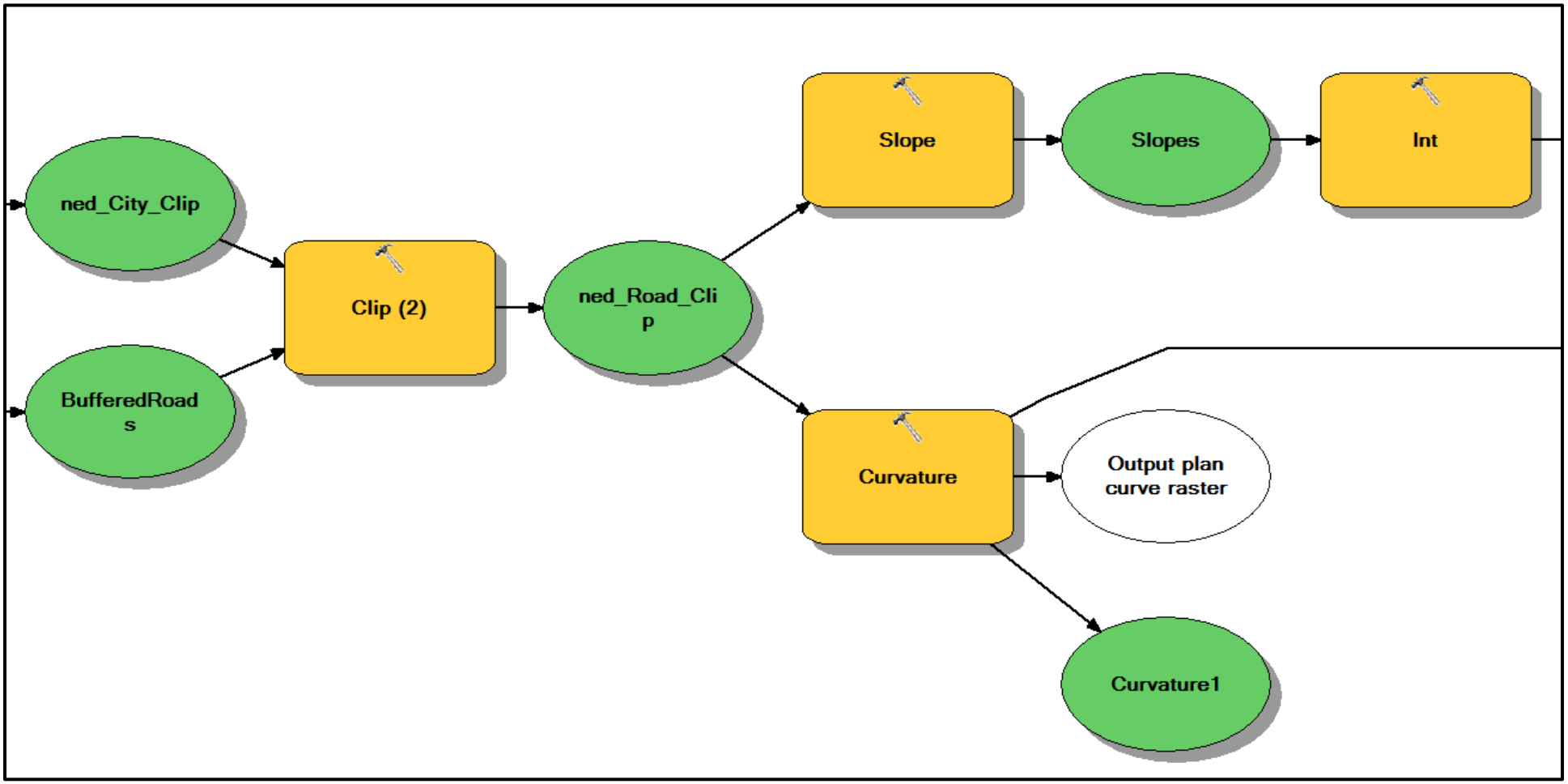
- Int - the Int tool is used to turn all values in a raster into integers. This tool is used to simplify any analysis or create the proper intermediate data that is compatible with the next tool.
- Curvature - calculates the curvature of a raster. Curvature is important to know how fast the slope is changing in a certain area.

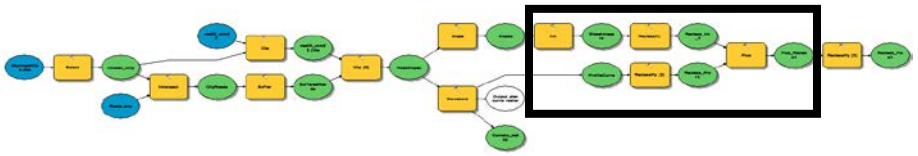
Example Model

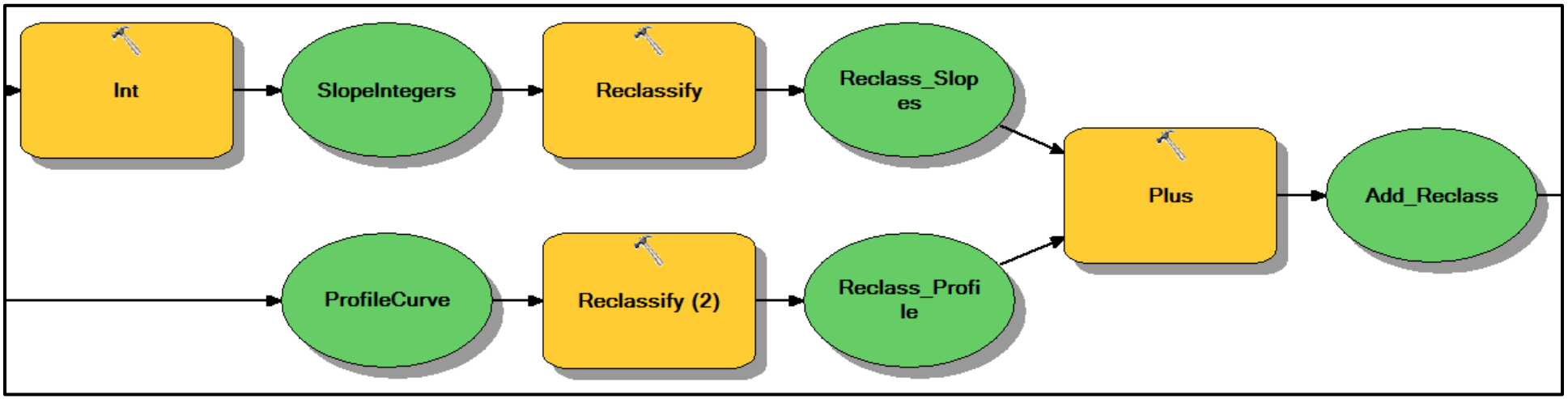


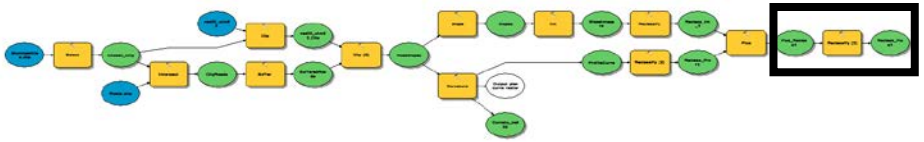


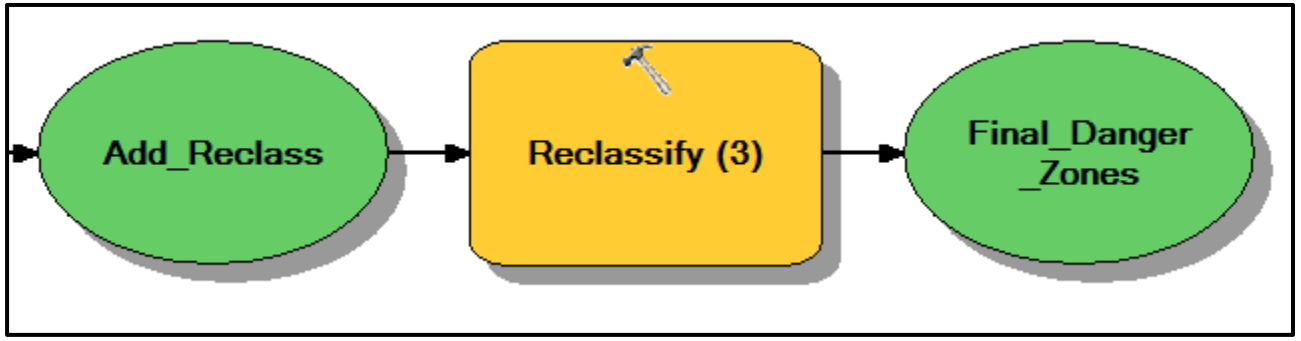



ned_City_Clip
BufferedRoads
Clip (2)
ned_Road_Clip
Slope
Slopes
Int
Curvature
Output plan curve raster
Curvature1




Int
SlopeIntegers
Reclassify
Reclass_Slop
es
Plus
Add_Reclass
ProfileCurve
Reclassify (2)
Reclass_Profi
le




Add_Reclass
Reclassify (3)
Final_Danger
_Zones

Step by Step Solution

For an advanced GIS student, the information up to this point is all you need to complete the assignment and create an output map from the results. Feel free to try conducting the analysis using only the information provided above. If you need specific steps, follow the instructions.

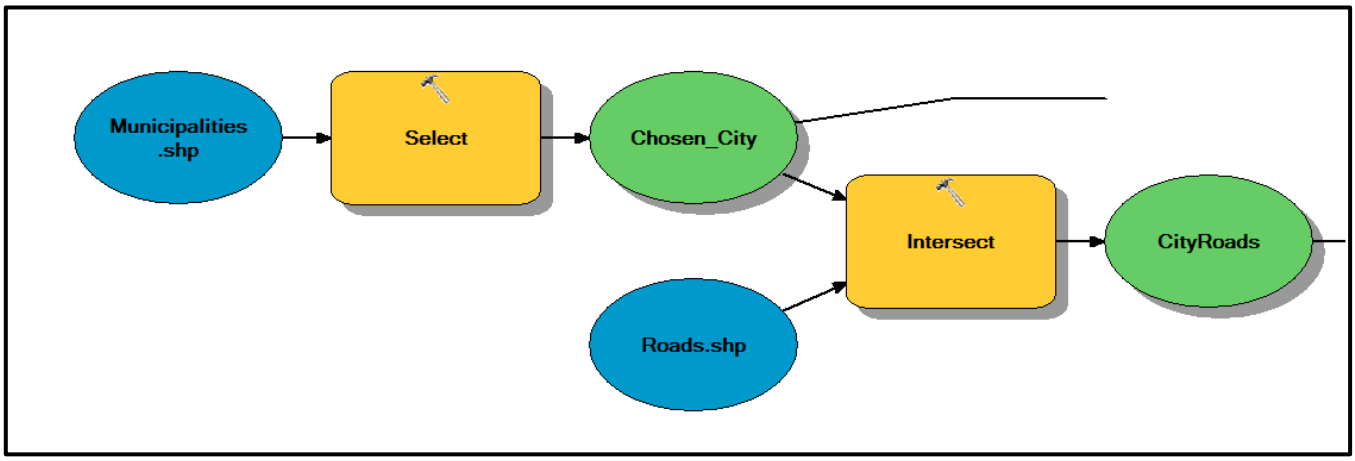


Figure 1 – Using the Select and Intersect tools in Model Builder.

Step 1

After downloading the data, use the select tool to identify the target city--Salt Lake City in this case--from the attribute table. The chosen city is then intersected with Roads.shp as shown in figure 1.

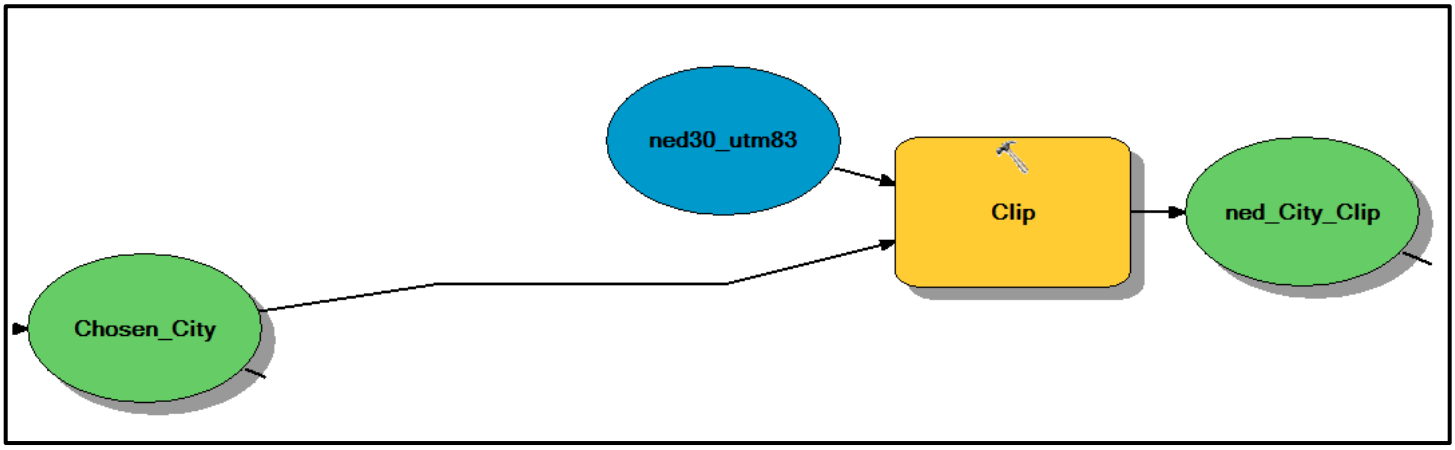


Figure 2 – Using the Clip tool in Model Builder.

Step 2

Clip the Salt Lake City data with the NED raster data to get a raster datafile that just covers the Salt Lake City polygon area (instead of the entire state of Utah, this step makes loading the map and running the model go much faster)

Step 3

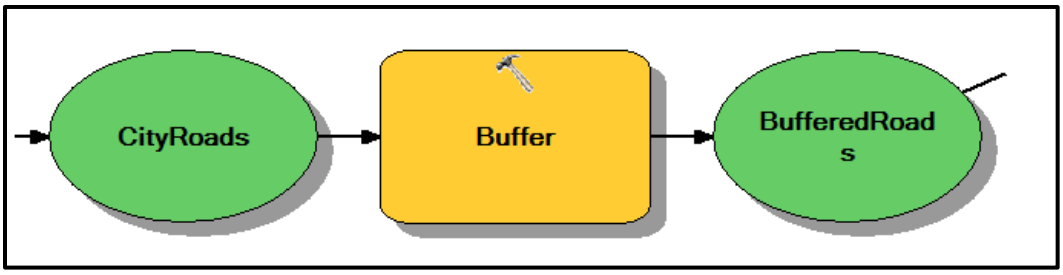


Figure 3 – Using the Buffer tool in Model Builder.

Using the buffer tool, set a buffer of 10 feet around all of the roads in Salt Lake City. Remember to set dissolve type to “ALL”.

Step 4

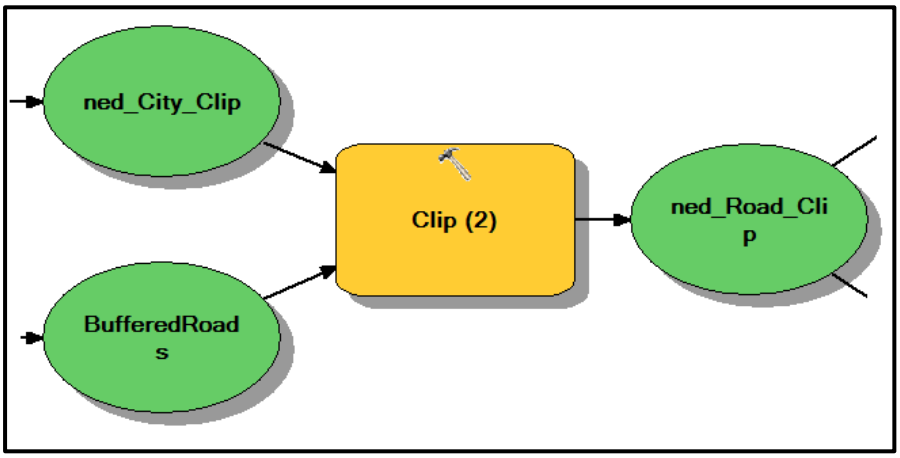


Figure 4 – The Clip tool in Model Builder.

To get a NED raster of just the area covered by roads, use the clip tool (different from the intersect tool) and check two boxes, “Use Input Features for Clipping Geometry” and “Maintain Clipping Extent” as shown in Figure 5.

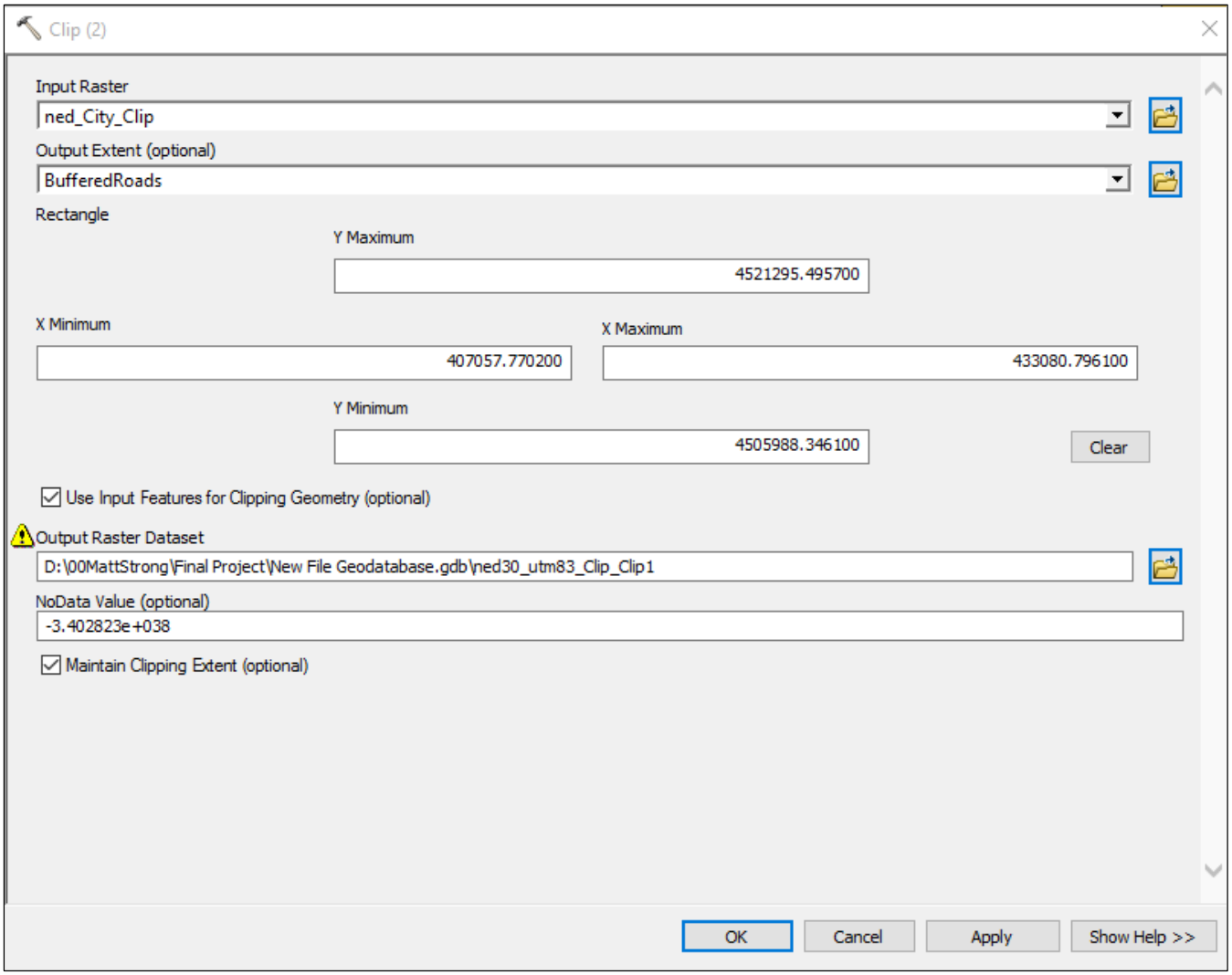


Figure 5 – Setting up the Clip tool for this model.

Step 5

Take your newly made raster of just the roads and run it through the curvature function. Be sure to define a location for the output profile curve raster as that is what you will want to use in the following steps. You will notice that the output plan curve raster bubble stays white. Don't worry about this, you will not need this data set. This tool will also automatically output a normal curvature raster as well which will not be used in this lab. See figure 7 for more clarification.

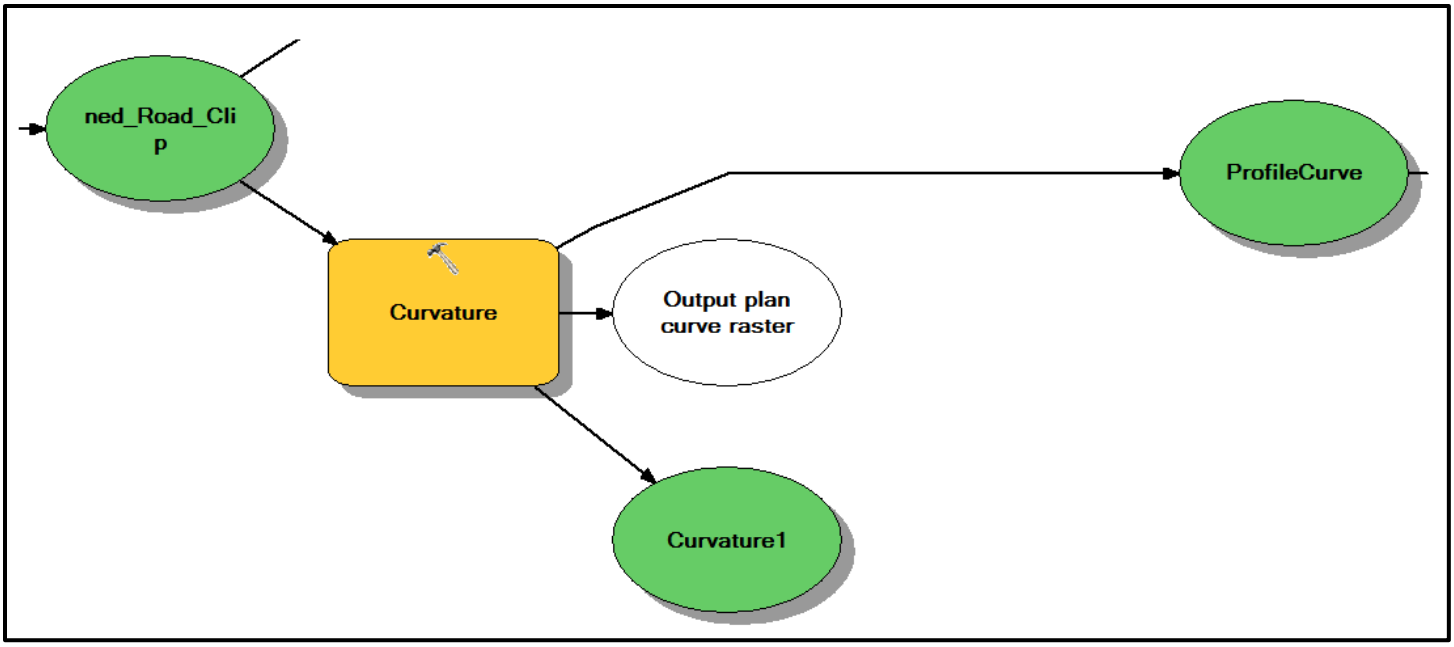


Figure 6 – The Curvature tool in Model Builder.

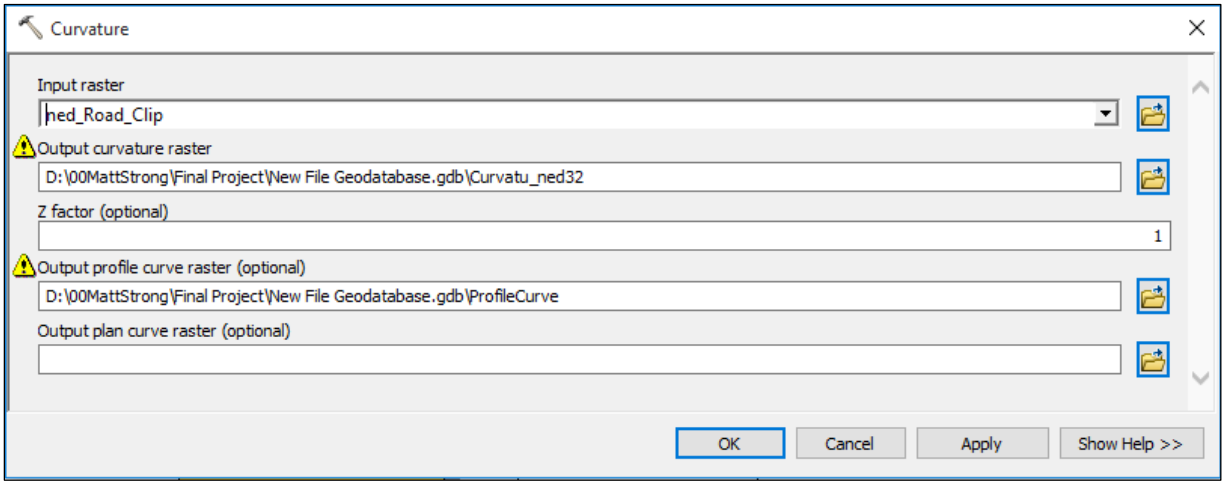


Figure 7 – Setting up the Curvature tool for this model.

Step 6

Now, with the same new raster of just the roads that you used in step 5, run that same raster through the slope tool. Be sure to set the output measurement to “DEGREE”. This will output a raster dataset with information of the slope of the road. Next, run your slope raster through the integer tool. This turns all of the slope values into integer values, which makes it easier to reclassify later.

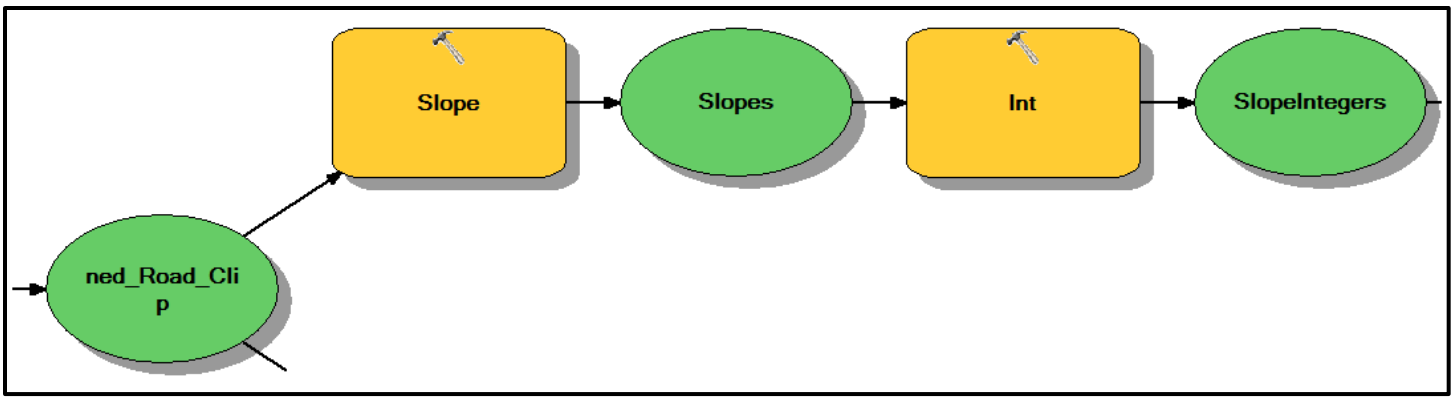


Figure 8 – Using the Slope and Integer tools in Model Builder.

Step 7

Send your new slope integers data set through the reclassify tool. Set all slope values between 0 and 6 to 0 and all slope values between 7 and 16 to 1. Leave all no data cells as no data. See figured 10 for clarification on reclassification table.

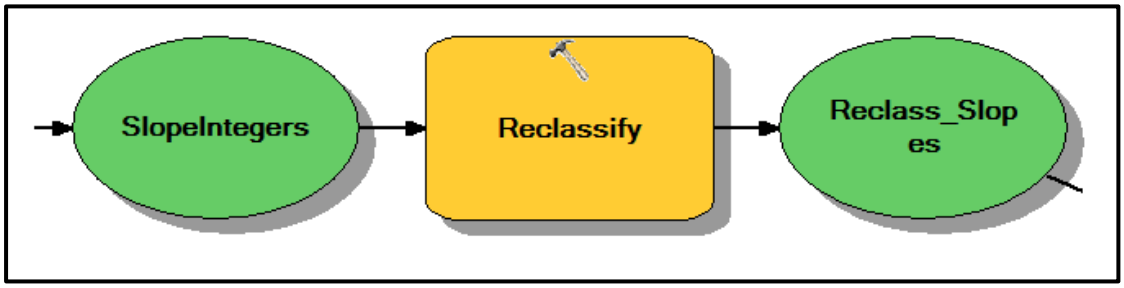


Figure 9 – Using the Reclassify tool in Model Builder.

Old values	New values
0 - 6	0
7 - 16	1
NoData	NoData

Figure 10 – Reclassification table used for this step.

Step 8

Now we will send the profile curve data set that was created previously, through the reclassify tool. Set all values between -2 and -1 to 1, all values between -.99 and 99 to 0, and all values between 1 and 2 to 1. Again, leave all no data cells as no data. See figure 12 for clarification on reclassification table.

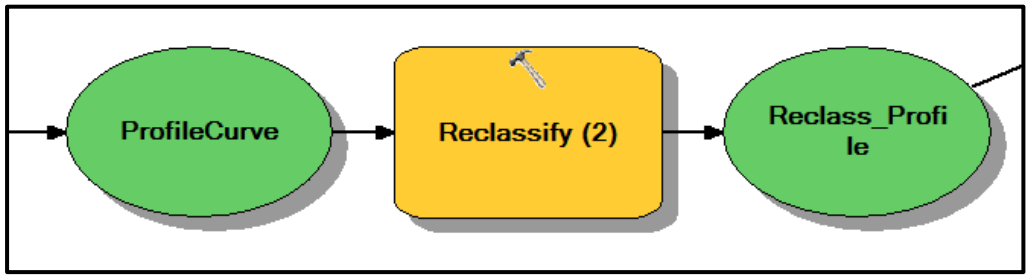


Figure 11 – Using the Reclassify tool in Model Builder.

Old values	New values
-2 - -1	1
-0.99 - 0.99	0
1 - 2	1
NoData	NoData

Figure 12 – Reclassification table used for this step.

Step 9

With your newly reclassified slope and profile data sets, we will put them through the plus tool to add the values together. With that new data set, reclassify all 0 values as 0, all values between 1 and 2 as 1, and leave all no data values as no data. See figure 14 for clarification on reclassification table. This will create your final output showing danger zones as having a value of 1.

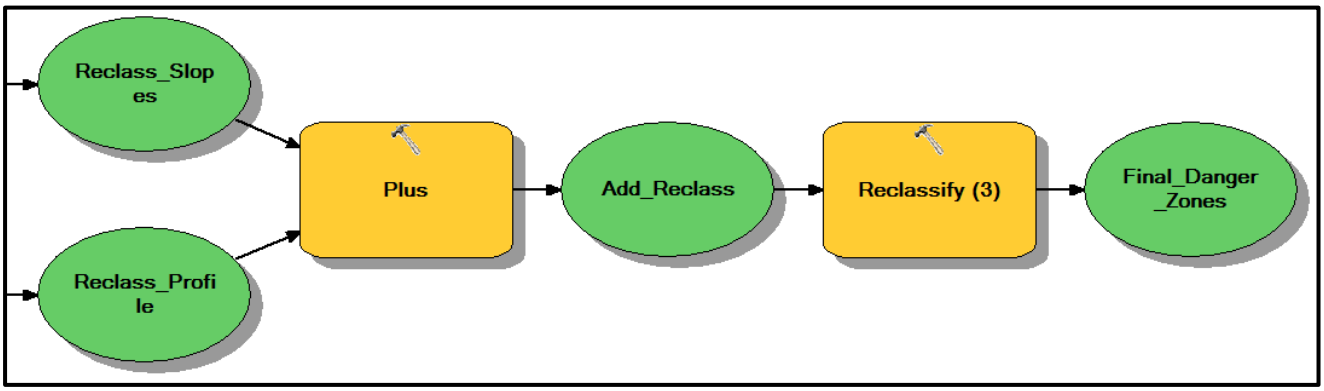


Figure 13 – The Plus and Reclassify tools in Model Builder.

Old values	New values
0	0
1 - 2	1
NoData	NoData

Figure 14 – Reclassification table used for this step.

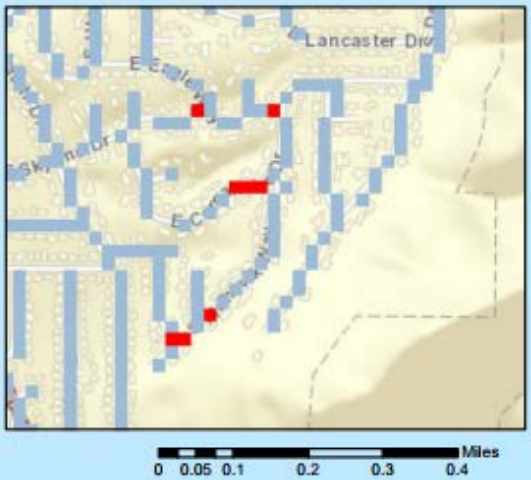
Deliverables

Construct a single ModelBuilder model that will prepare all of your input data for the autonomous vehicle danger-zone analysis. Conduct the analysis, and create a map from the analysis indicating the locations of danger zones in Salt Lake City where LIDAR might not function. Include in your map, several different zones referencing the areas of hazard, and where on your map they are located.

Write a brief project report describing the project requirements, the study area chosen, the methods used to complete the project, potential errors or flaws in the parameters, a detailed description of your model, and a layout view of your final map. Make sure to review over the rubric at the end of this chapter for the full requirement for the laboratory exercise.

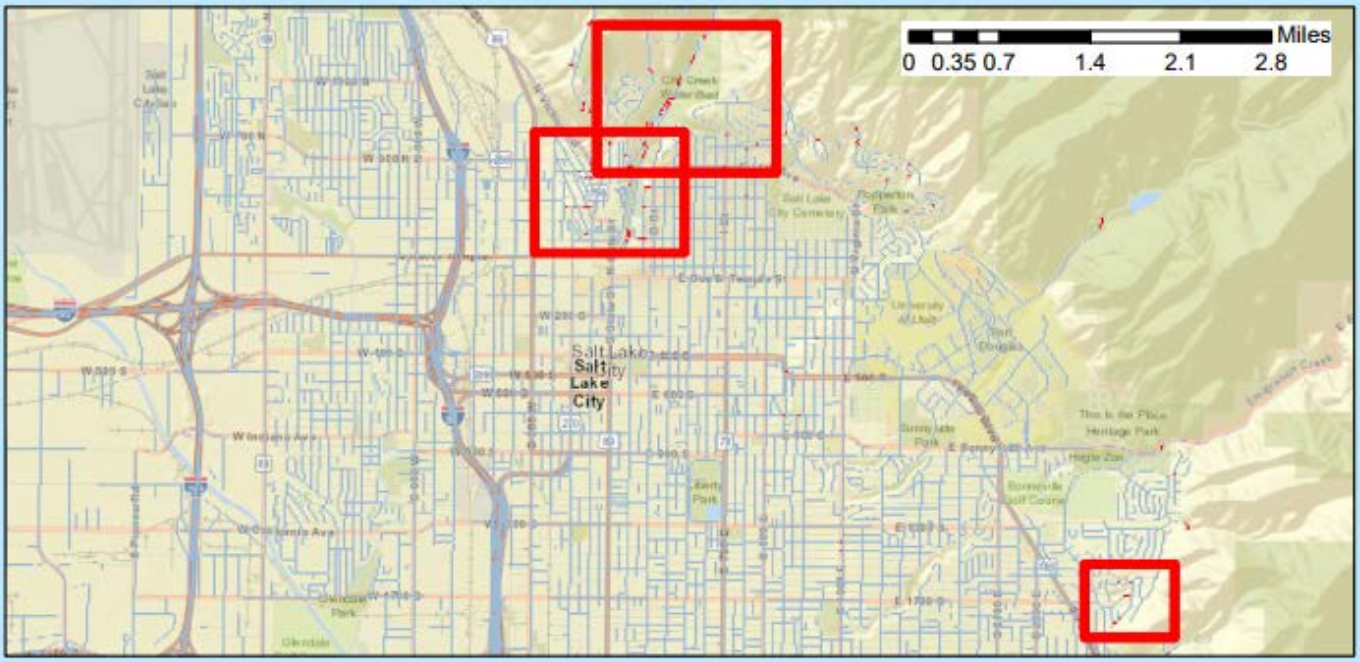
Item	Points
Assignment Title, Author Name, Date, Course Name	/5
Brief summary of the requirements of the project	/5
Describe your model · List each of the tools used: (2 pts) · List tool settings applied for the analysis (could someone repeat the assignment using your lab report?): (2 pts) · List all input, intermediate, and output datasets: (2 pts) · Describe each input dataset including type (point, line, polygon, raster) and the source of the data: (2 pts) · Describe each output dataset (point, line, polygon, raster): (2 pts)	/10
· One or more full pages (8.5x11) showing your model (5 pts) · All text is readable (**10 point font minimum**) (3 pts) · All tools and datasets are shown (2 pts)	/10
· What areas are potential LIDAR danger zones? (2 pts) · Are your results as expected or did you find anything interesting or different? (3 pts)	/5
Make a full page (**8.5x11**) map showing the results of your LIDAR danger zones analysis. · Map Title: (1 pt) · Neat Line: (1 pt) · North Arrow: (1 pt) · Scale Bar: (1 pt) · Text box with author name, date map projection: (1 pt) · Outline of LIDAR Danger Zones on map and legend: (5 pts) · Each data set clearly symbolized: (1 pt) · Label indicating location of most saturated danger zones: (1 pt) · Basemap or other labeled reference data: (1 pt) · Zoomed to an appropriate scale for viewing analysis results: (1 pt) · All text is legible on printed map: (1 pt)	/15
Bounus Task: Repeat the lab exercise with a different set of data. Include in your report what data you used, how you acquired it, what, if anything, you changed to complete the exercise efforts. Also, include an additional full page map showing your results.	Instructor's Discretion

Level 3 Autonomous Danger Zones



Legend

- Autonomy
- Driver Assisted

Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Matt Strong & Nate Lant
Final Project
December 12, 2017
NAD_1983_UTM_Zone_12N