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GEO 326G/387G

GIS Final Project: Delineation of landslide-prone areas on basis of slope, soil and/or geology grids in Yosemite National Park, California

Introduction

Problem Overview

For this project, I have will be delineating the landslide-prone areas at the Yosemite National Park, California. I also formulated a method to determine this land slide prone areas in the park by ranking certain features such as the elevation which was used to calculate the slope, permeable rocks and vegetation within the park. The landslide prone areas were then determined using the Spatial Analyst Tool within ArcGIS. This study shows that permeable rocks and vegetation has an effect on landslide most especially in areas where the elevation is slow. Furthermore, since Yosemite National is well known for the high amount a snowmelt (waterfall) within a short period and the large human activities in this area the water flow line will also be used to delineate the areas that are will be prone to landslide.

Background

Yosemite National Park is located in the central Sierra Nevada of California and it is one of the first wilderness parks in the United States, is best known for its water falls, but within its nearly 1,200 square miles, you can find deep valleys, grand meadows, ancient giant sequoias, a vast wilderness area, thousands of lakes and ponds and much more. The park has an elevation range from 2,127 to 13,114 feet (648 to 3,997 m) and contains five major vegetation zones: chaparral/oak woodland, lower montane, upper montane, subalpine, and alpine. The geology of the Yosemite area is characterized by granitic rocks and remnants of older rock. The geologic story of Yosemite National Park can be considered in two parts: (1) deposition and deformation of the metamorphic rocks and emplacement of the granitic rocks during the Paleozoic and Mesozoic; and (2) later uplift, erosion, and glaciation of the rocks during the Cenozoic to form today's landscape

Yosemite is famous for its high concentration of waterfalls in a small area. Numerous sheer drops, glacial steps and hanging valleys in the park provide many places for waterfalls to exist, especially during April, May, and June (the snowmelt season). Located in Yosemite Valley, the Yosemite Falls is the highest in North America at 2,425-foot (739 m). Also in Yosemite Valley is the much lower volume Ribbon Falls, which has the highest single vertical drop, 1,612 feet (491 m). Yosemite's hydrologic resources are fascinating to examine because the park lies at the heart of one of the most extreme Mediterranean climates on earth. Such climates are characterized by cool, wet winters and long, dry summers. In the case of Yosemite, most precipitation falls in the form of snow that accumulates above 6,000 feet (1,830 meters) during the winter, making a natural water tower that slowly releases melt-water through the spring and early summer. This slow release of water nourishes lower regions well into the hot dry season.

Objective

The objective of this study is to determine the areas that are prone to landslide on the basis of slope, soil and/or geology grid and water flow area/line. For this analysis, the ArcGIS software will be used.

Data

Data required

1) Elevation (DEM)

2) Geologic Map

3) Hydrographic data

4) Boundaries, land use and land cover

Data acquisition

In other to delineate landslide prone areas, the Digital Elevation Model (DEM) was downloaded from the USGS seamless server which is available to the public (http://seamless.usgs.gov/website/seamless/viewer.htm), and in other to download this file from the server, I highlighted the region to be downloaded. Other additional features (boundaries, land use, land cover, roads, and streams) were also downloaded from this site by selecting the areas of interest from the drop down menu in the download button and display button and then highlighting the area within the Yosemite National Park which is my area of interest (Figure 1) a new window appears with an option to download all the files selected.

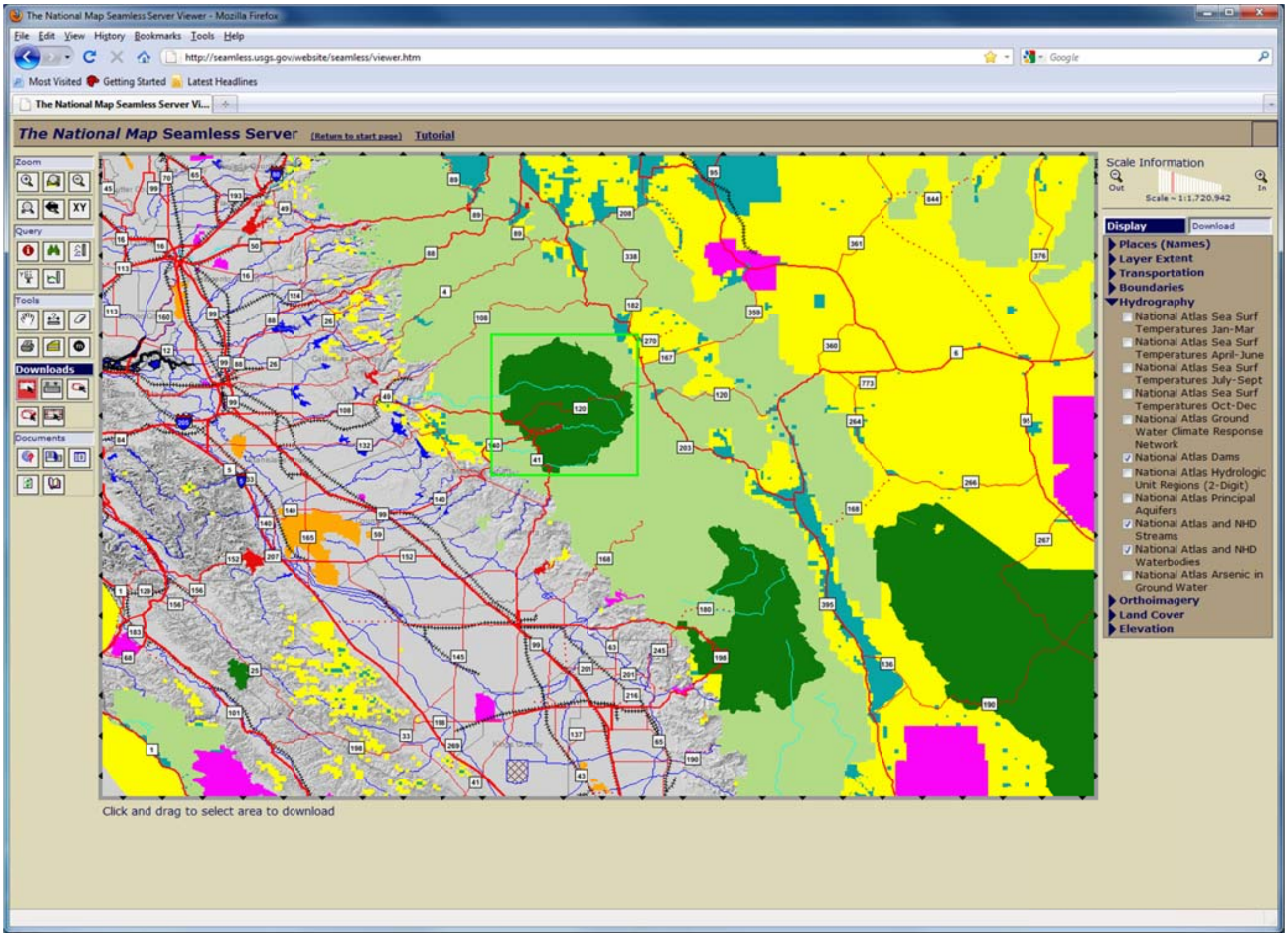


Figure 1: USGS seamless server showing the Yosemite National Park highlighted in green.

For this project, I used geologic map of the Yosemite National park freely available from the United States Geological Survey (http://pubs.usgs.gov/imap/i1874) and the shapefiles for the hydrographic data was also downloaded from the United States Geological Survey NHD Geodatabase (http://nhdgeo.usgs.gov/viewer.htm).

Data preprocessing

Data was collected from different sites and were extracted. In other to use this data, some of the files needed to be converted to useable formats. The geologic map for Yosemite National Park was downloaded in the form of .eoo and was converted in ArcCatalog by using the ArcToolbox >Coverage Tools > To Coverage > Import from interchange file, as shown in the Figure 2 below;

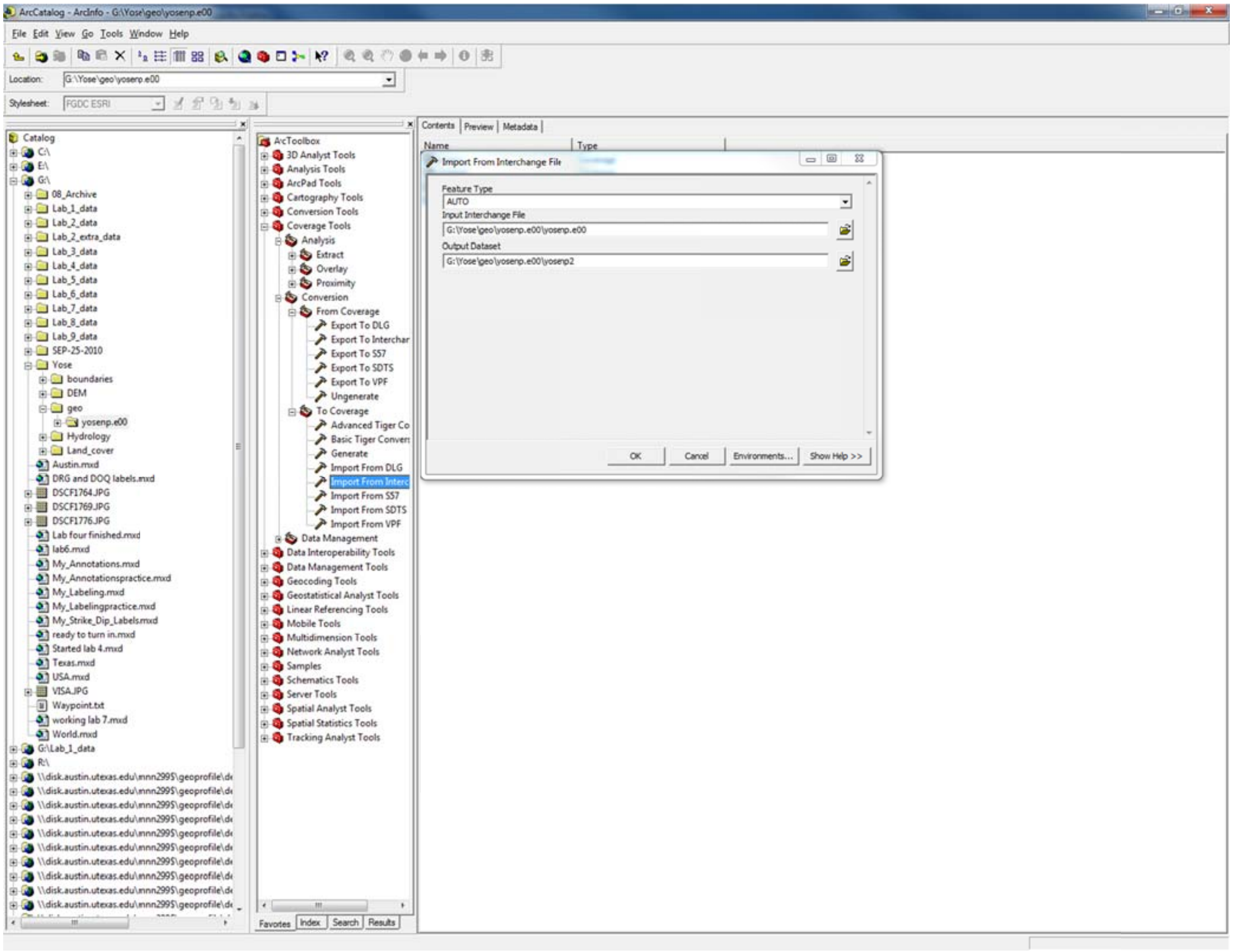


Figure 2: Converting .eoo file in ArcCatalog to a useable format.

After converting the geologic map it was then projected from Clarke 1866 to NAD 1983, in other for it to be in the same coordinate system as the other data collected. This was achieved using the ArcCatalog and clicking on the ArcToolbox > Data management tools >Projection and transformation >Feature > Project. A new window pops up, and the input dataset form field will be the geologic data that will be converted while the icon for the output coordinate system allows us to select a predefined coordinate system in this case NAD 1983.

The DEM was also extracted and was downloaded in four blocks shown in Figure 3 below, which was projected to NAD 1983. In other to convert this mosaic to a raster in ArcMap, I selected the ArcToolbox > Data Management tools > Raster > Raster Dataset > Mosaic to New Raster, a new window pops up and the four blocks was downloaded to the input raster, the output location was defined, and the coordinate system was set to NAD 1983. This produced the raster shown in Figure 4 below.

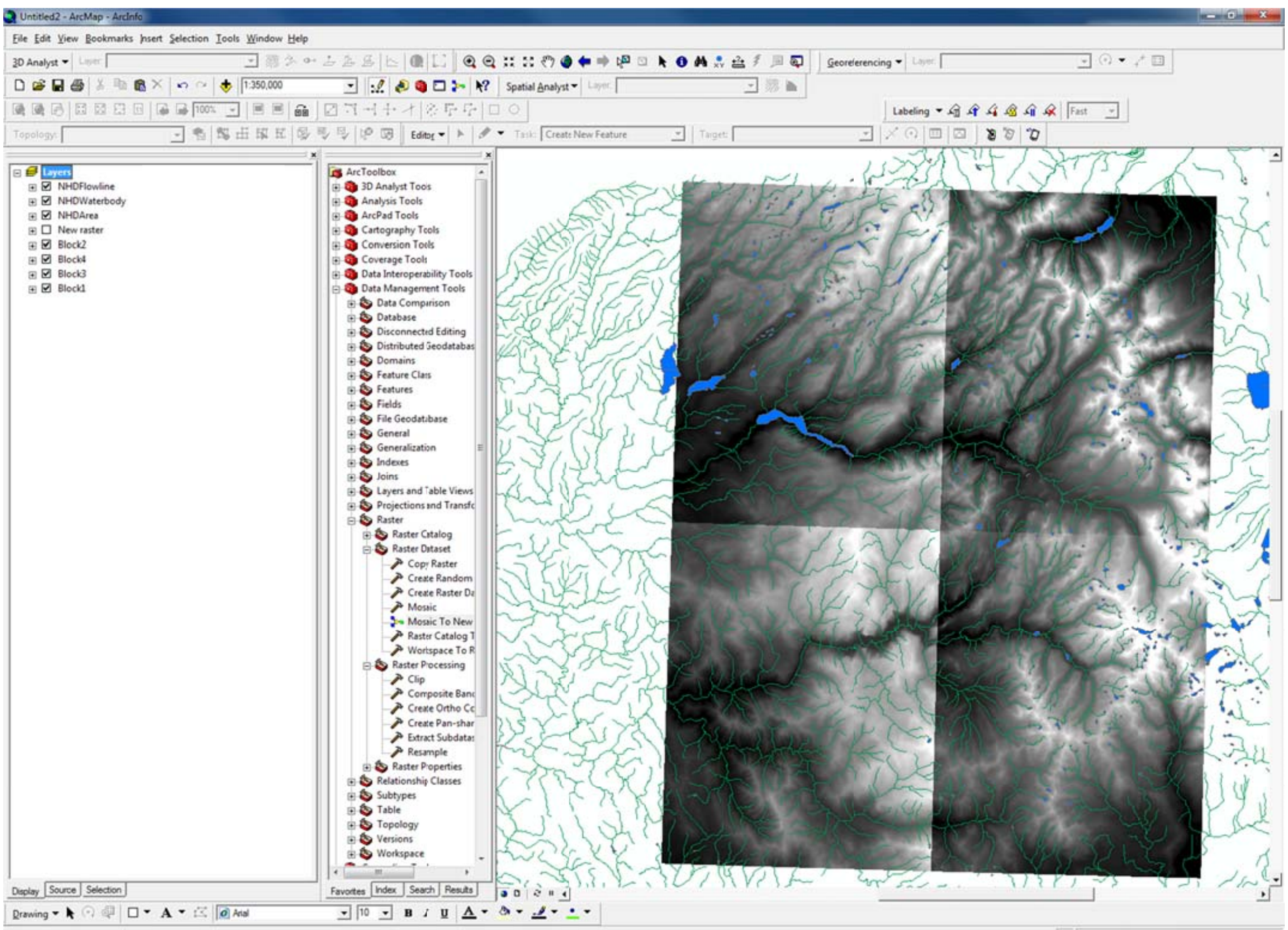


Figure 3: Downloaded blocks of Digital Elevation Model, Water bodies and Water flowline.

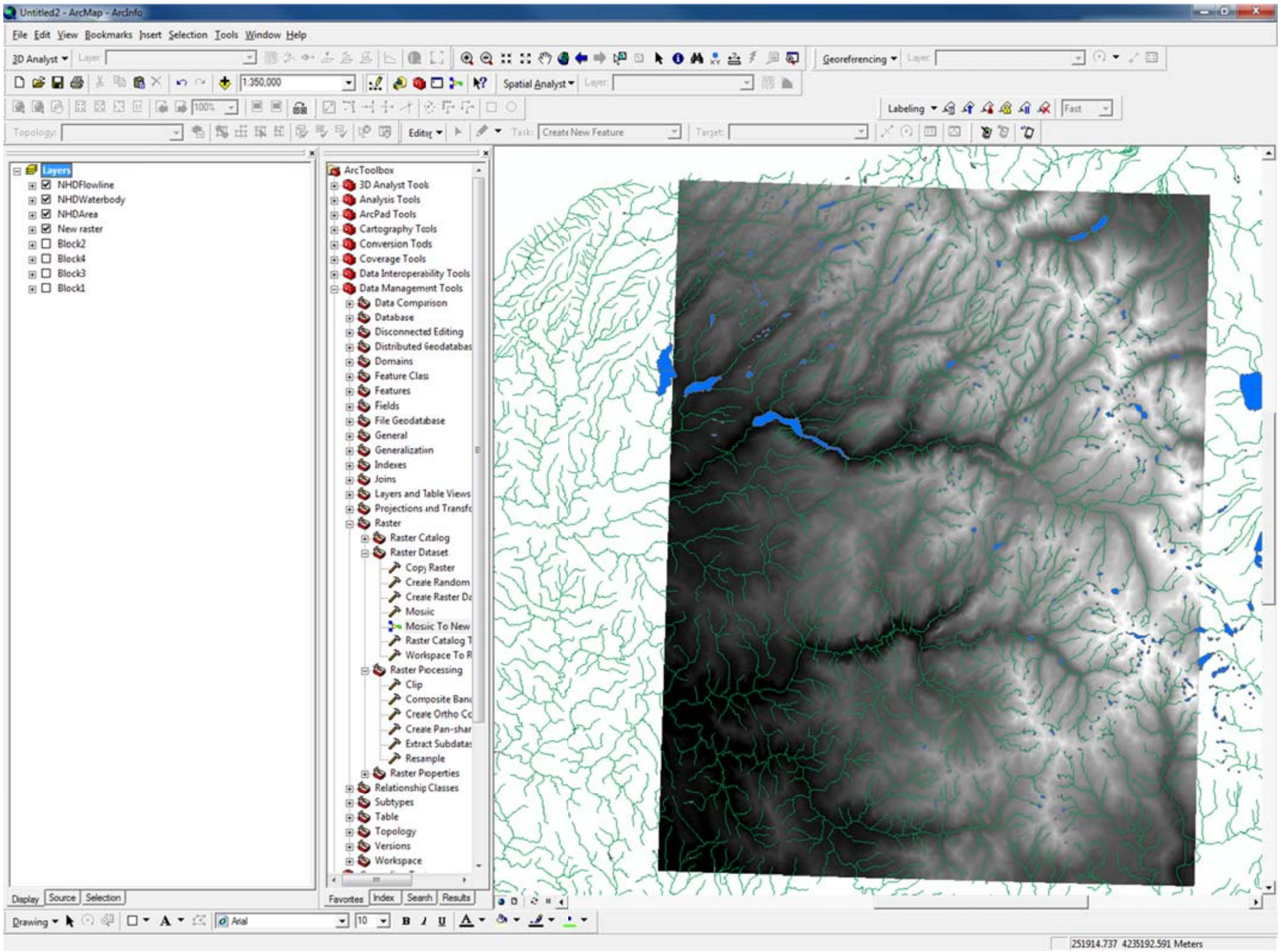


Figure 4: Mosaic covering the Yosemite National Park converted to Raster

The boundary that was downloaded from the USGS website contained different features in the Mariposa County where Yosemite Park is located. Hence, in other to extract the area covered by Yosemite National park, features covered by the park was selected and these features where exported to the table of content and merged using the editor tool bar. This was done by clicking on "start editing" from the dropdown menu in the editor tool bar and then selecting the features to be merged. From the drop down menu in the editor tool bar, click on merge and select the attribute table where the new polygon will be merged to, from the new window that pops up. This will merge the polygons and will give the result shown in Figure 5.

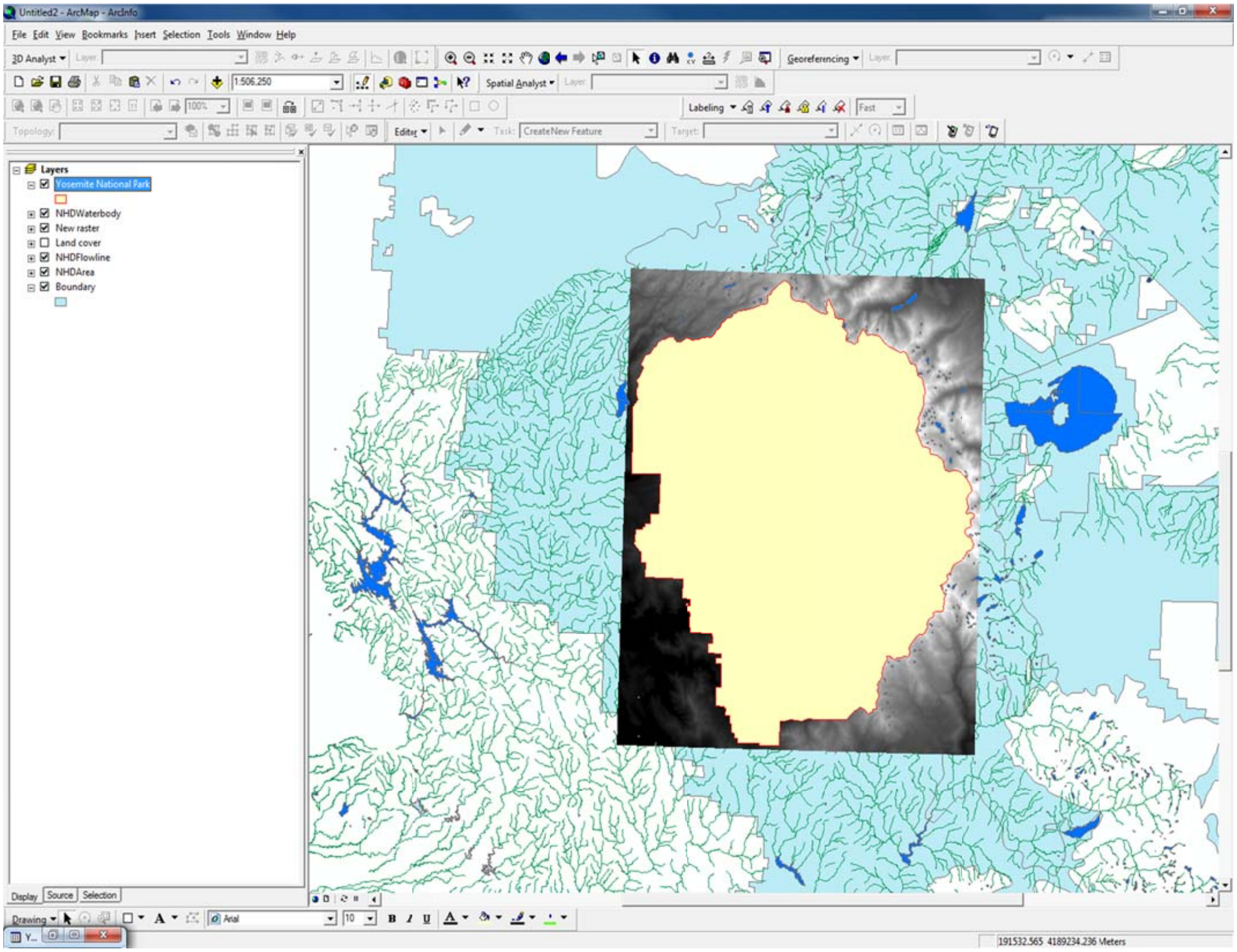


Figure 5: Area in Yellow covered by the Yosemite national Park.

Next, I tried to remove all the features downloaded that were not within my area of interest (Yosemite National Park). Hence, using the "select by location" from the selection tool, I selected water flow line and water body that are within the Yosemite National Park and exported the files as can be seen in Figure 6 below.

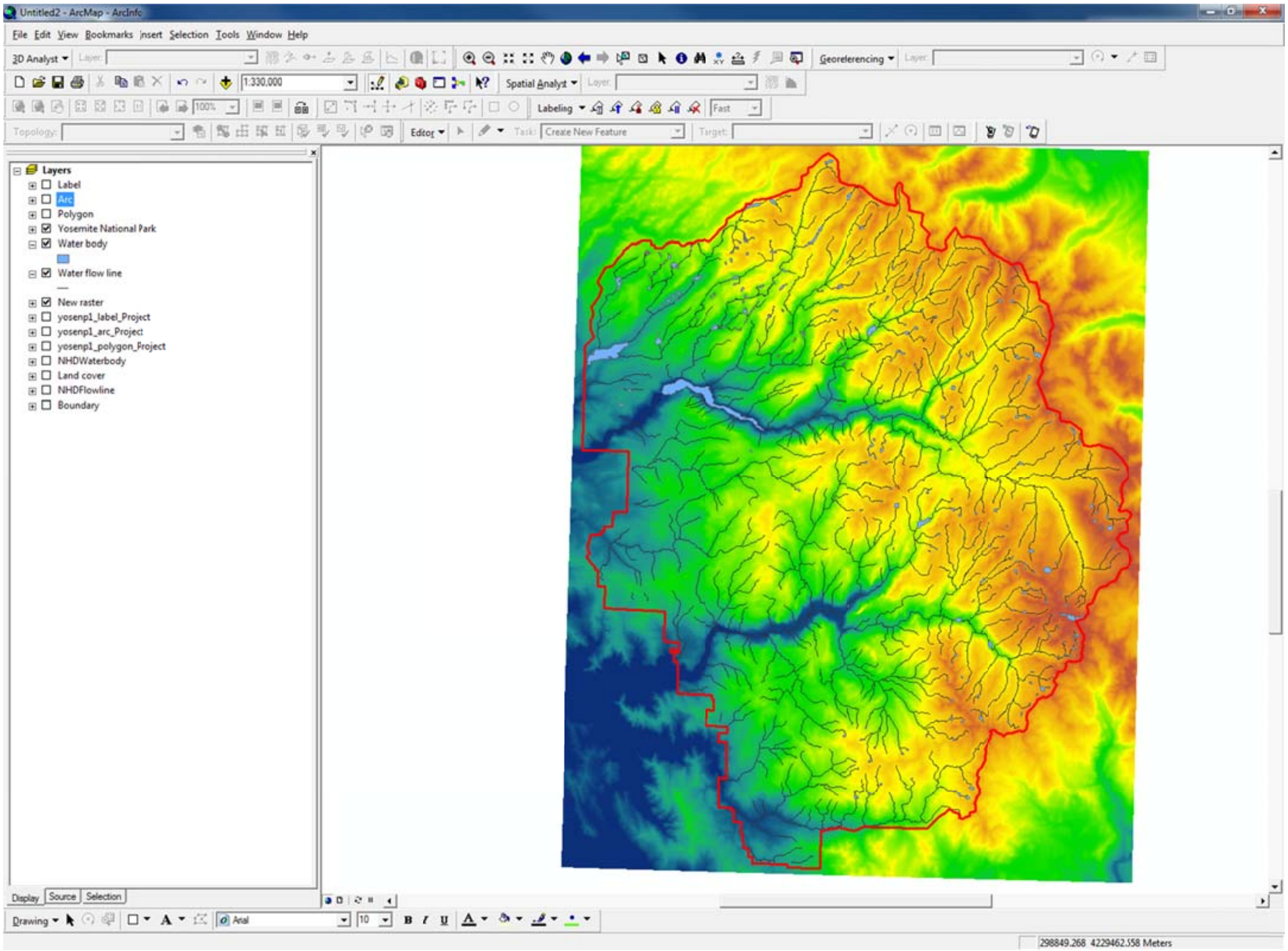


Figure 6: Water flow line and Water bodies that are within the Yosemite National Park.

In other to clip the area covered by the Yosemite National Park to the raster created and also to clip the land cover and geologic map showing the different rock types, I set all the coordinates to NAD 1983 and for the raster, I used the spatial analyst tool. By selecting "option" from the dropdown menu on the spatial analyst tool bar, I set my working directory and my Analyst mask to the boundary for the Yosemite national park. Next, using the Raster calculator from the same drop down menu in the spatial analyst tool bar, I double clicked on the raster and evaluated. This produced the result shown in Figure 7 below.

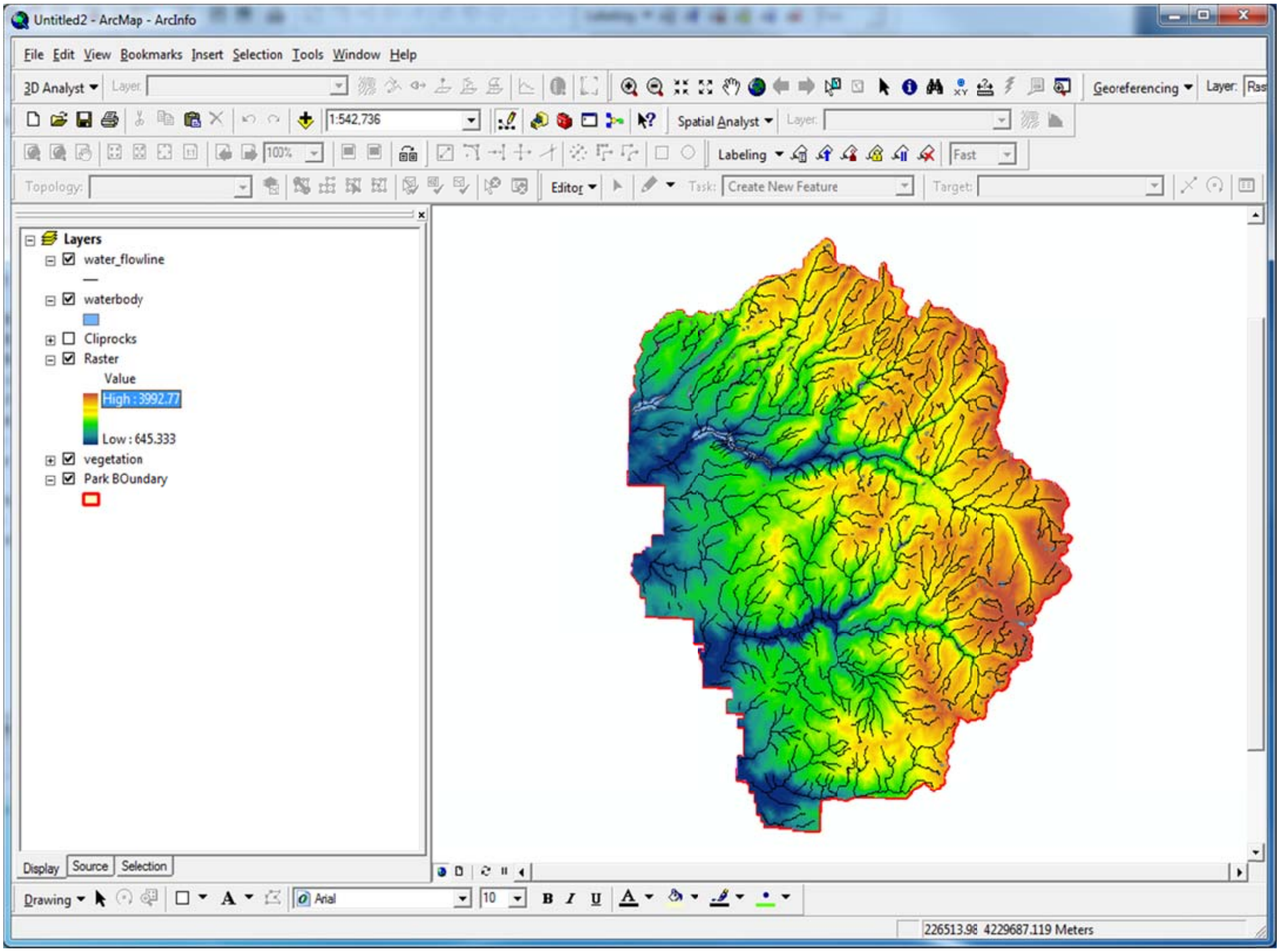


Figure 7: Map showing clipped raster, water bodies and flowline of Yosemite National Park.

Next, the geologic map was downloaded as shown in Figure 8 below and in other to clip the geologic map covered by the Yosemite National Park using ArcMap, I used the ArcToolbox > Analysis tools > Extract >clip. A new window pops up, where I defined my Input feature, clip feature which is the area covered by Yosemite National Park, and the output feature class, where I defined the location I want to save the new clip created. By right clicking on the new clip and selected the symbology from the properties menu, I added all the different rock types as shown in Figure 9 below.

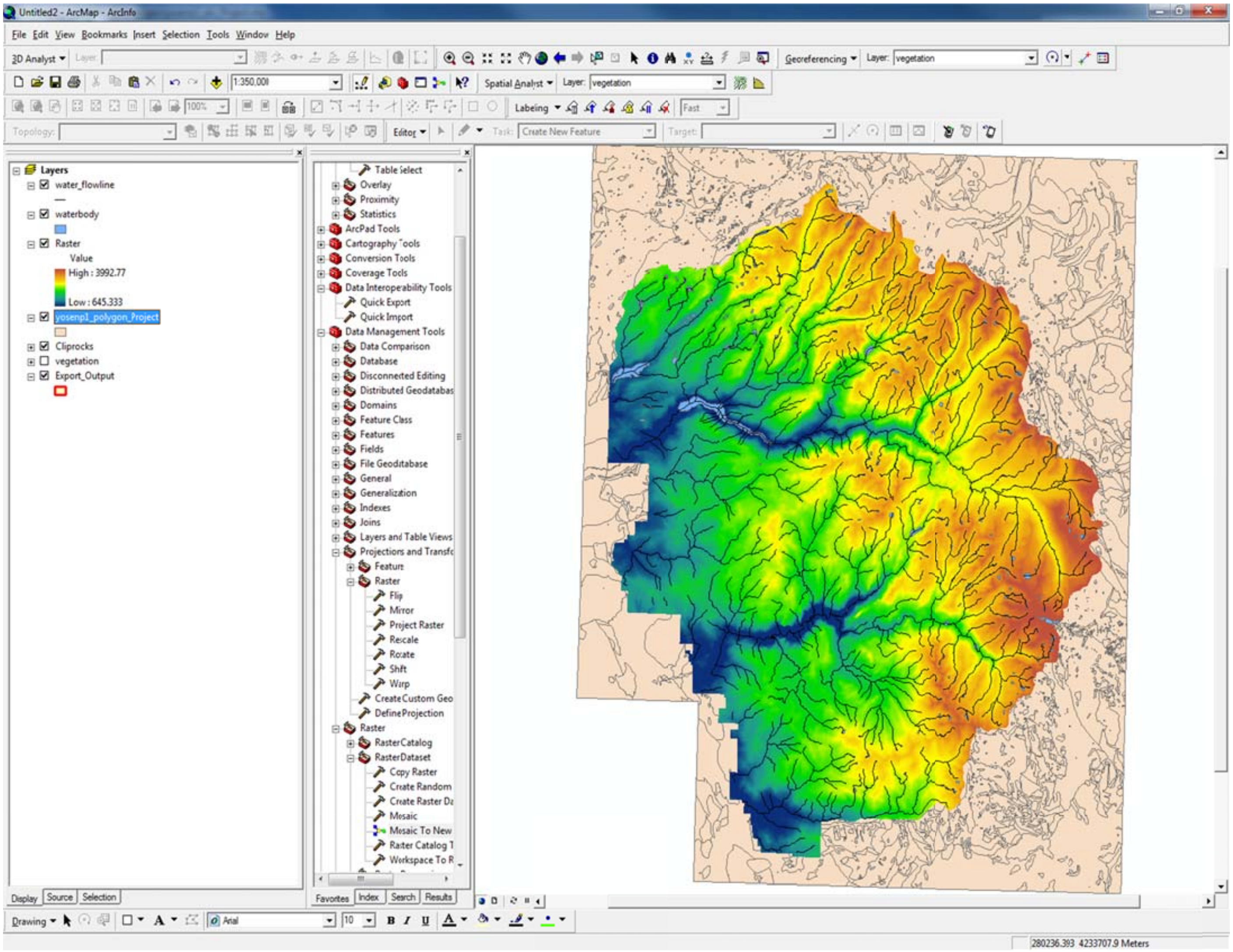


Figure 8: Raster covered by the Yosemite National Park and geologic map showing different rock types.

The same procedure was used to clip the Land cover to the area covered by the Yosemite National Park. It is important to ensure that all the data to be clipped are in the same spatial reference, otherwise the clip cannot be performed.

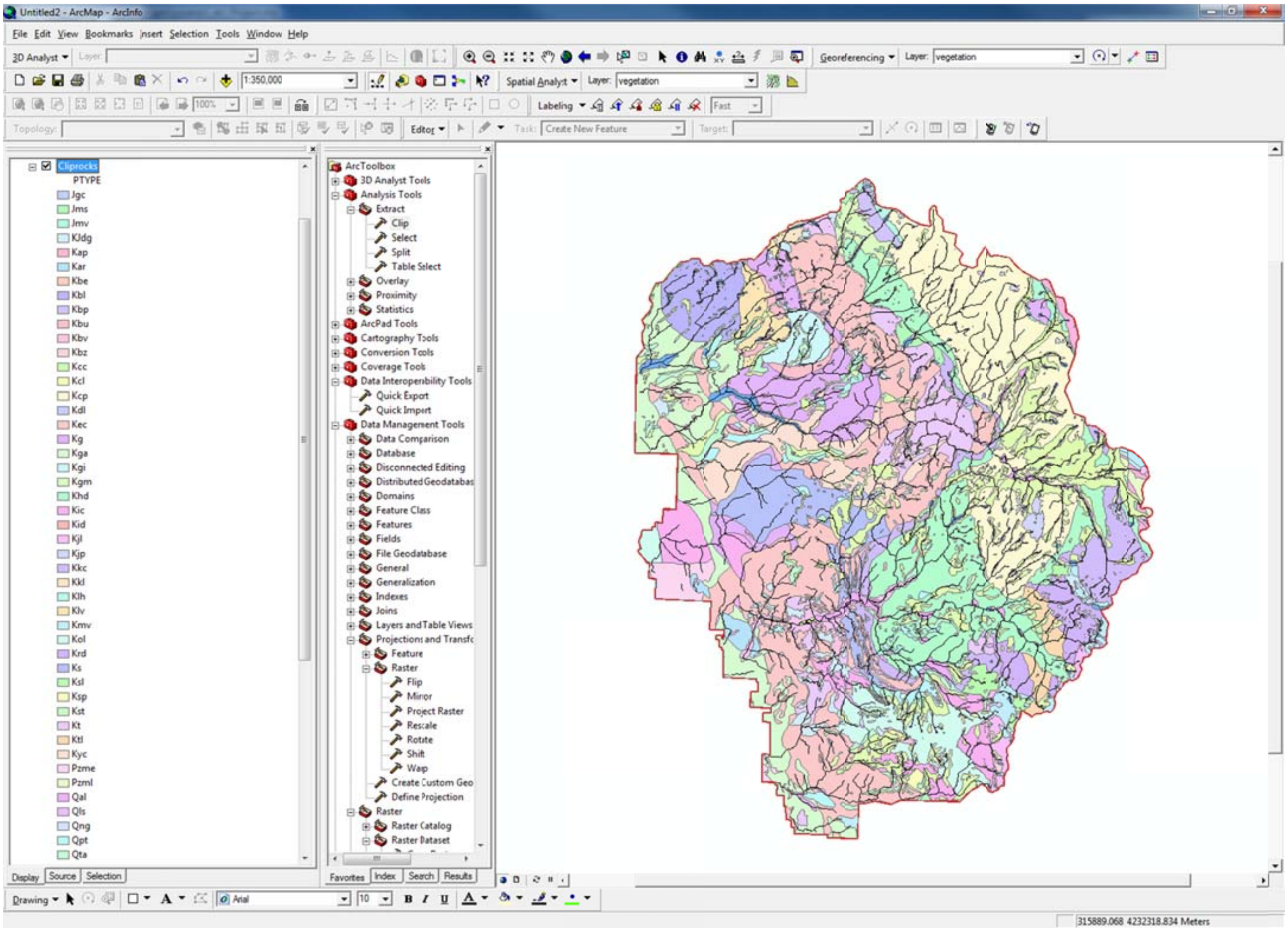


Figure 9: Geologic map showing area covered by the Yosemite National Park and the different rock types.

ArcMap Processing

In other to delineate the landslide prone area in the Yosemite National Park, I used the rank scheme I developed (Table 1) to rank the different rock types, slope (which was calculated from the elevation) and the vegetation. The procedure used is discussed below;

Table 1: Ranking scheme used for delineating landslide prone areas.

Rank	Geology	Slope	Vegetation
1	Water bodies	< 10 ^{o}	-
2	Soft rocks	10 – 20 ^{o}	Low
3	Glaciers	20- 30 ^{o}	Medium
4	Hard rocks	> 30^{o}	High

Creating a slope grid

In other to create a slope grid, I derive a secondary dataset from primary data sets and then created the slope grid by displaying the elevation layer and the park boundary and then using the Spatial Analyst toolbar and from the dropdown menu selecting, Surface Analysis > Slope. From the new window that pops up, select Elevation (m) as the input surface, and the output measurement in Degree so it follows the ranking scheme developed, the Z factor is 1 (i.e. horizontal and vertical units are the same, in this case meters), and the Output cell size is 100. I then specified an output raster, and clicked OK. This will produce the map shown in Figure 10 below.

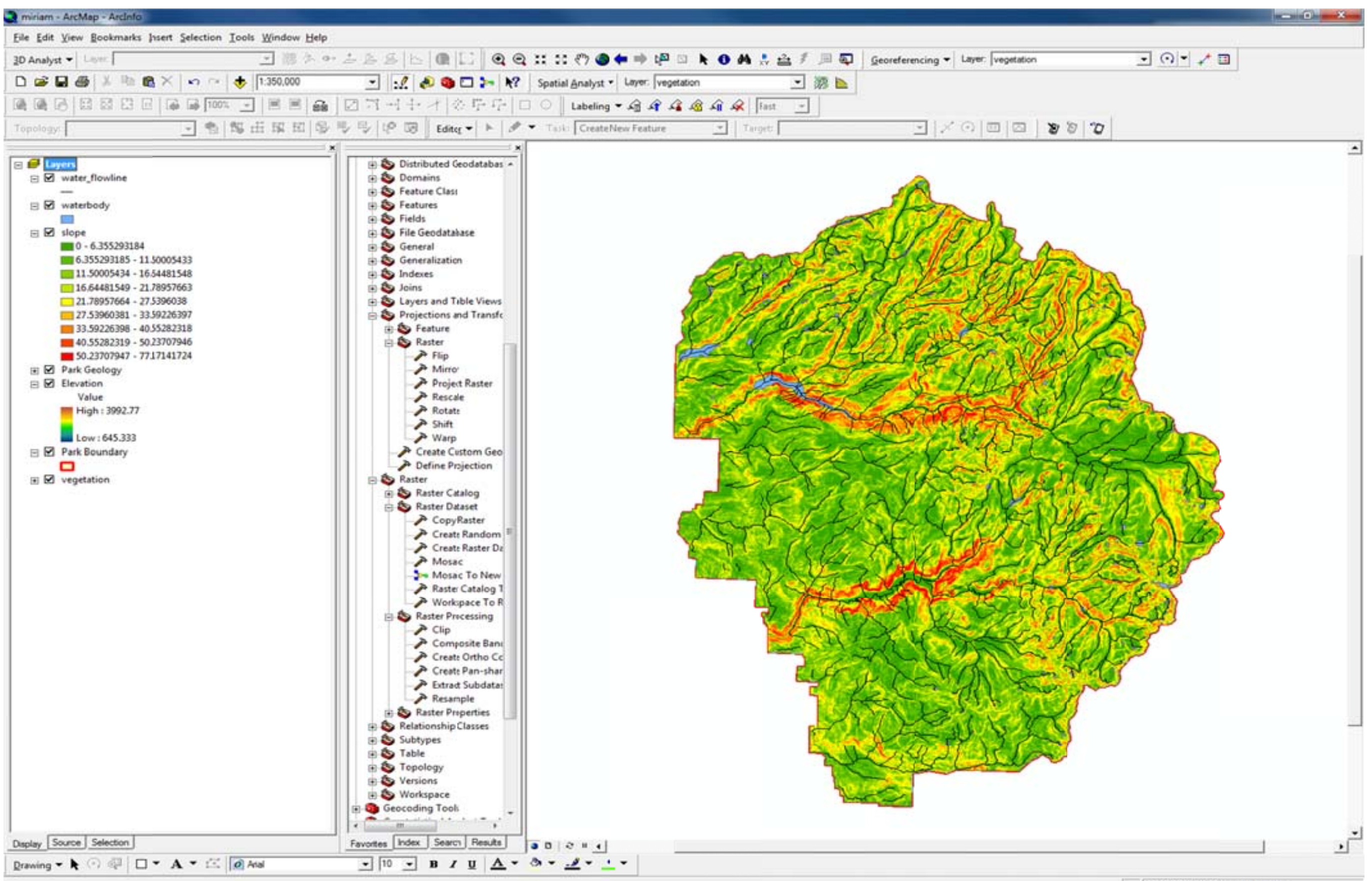


Figure 10: Map showing slope derived from elevation, Yosemite park boundary, water flow lines and Water body.

The next step was to create a geology vector layer. In other to do this I had to convert the geology to a raster layer so I can use it in my spatial analysis. Using the Spatial Analyst toolbar and from the dropdown menu, I clicked on Convert > Features to Raster. I then Selected the geology layer as the input, and the for the field, I created a new field in my attribute table called "codes" and the values in the codes was rank according to the different features types as shown in table 1 above. I use 100 as the output cell size, and then selected output raster name. I then clicked OK. The conversion took a few minutes and I ended up with a raster as shown in Figure 11 below. This raster cannot be symbolized with a vector layer file; this is now a raster and would need a raster layer file to symbolize the units.

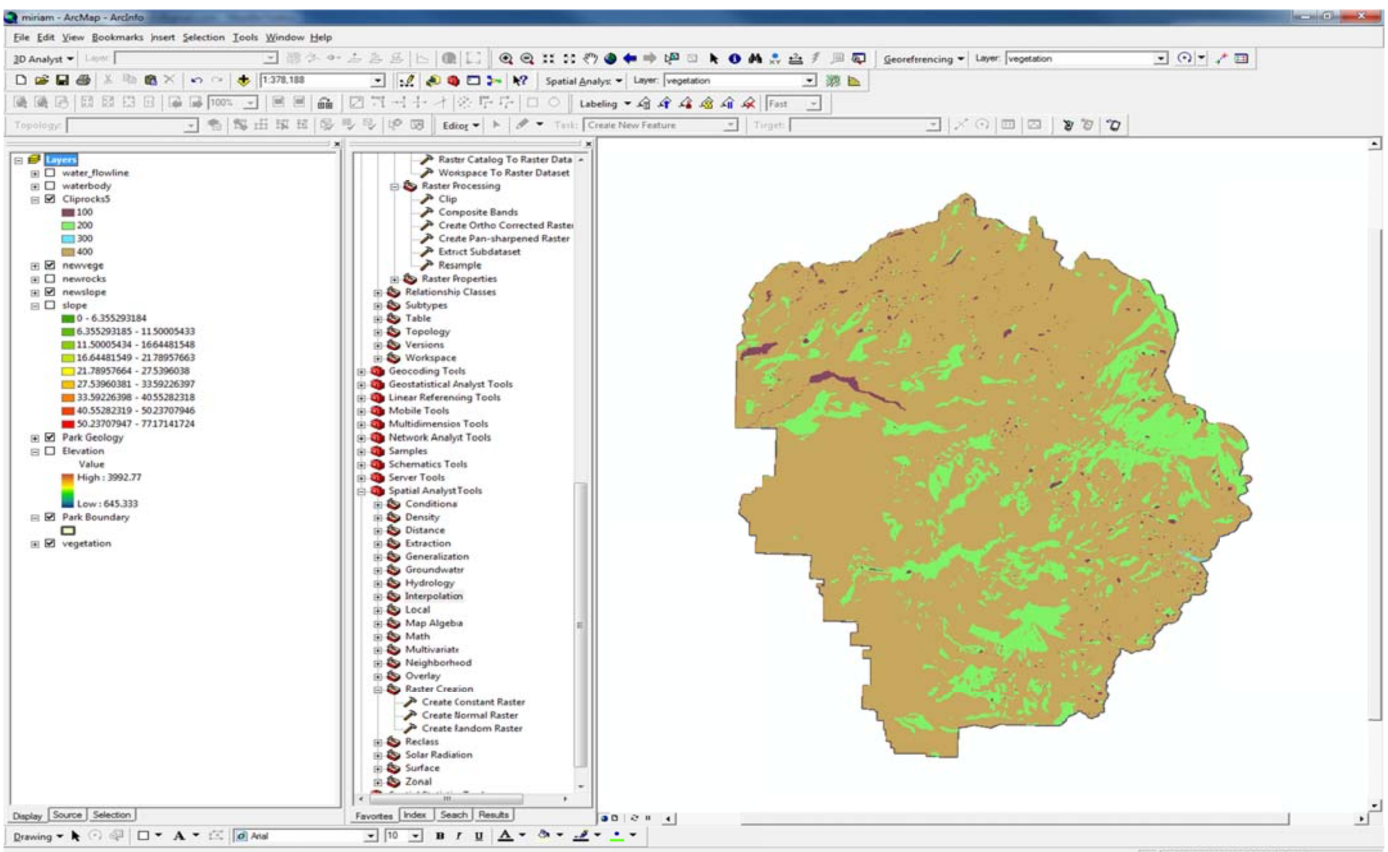


Figure 11: Geologic raster showing the four different ranks of rock types

Reclassifing data sets:

To reclassify the raster data sets using the ranking scheme shown in Table 1 above, I used the spatial analyst tool bar, and from the dropdown menu, I clicked on Reclassify, a new window now pops up (Figure 12) and since I will be reclassifying the slope created from the elevation and land cover raster, I use this as my input raster. I then clicked on classify and a new window (Figure 13) pops up, here, I can then change the method to any desired method and for this project, I will be using the Natural breaks which can be found from the drop down menu in methods from the classification box and since I have four classes I also select number four from the dropdown menu for classes, then I can manually divide my classes by shifting the bars with the mouse down, so I can get the four classes of slope or rock types that I have in the ranking scheme.

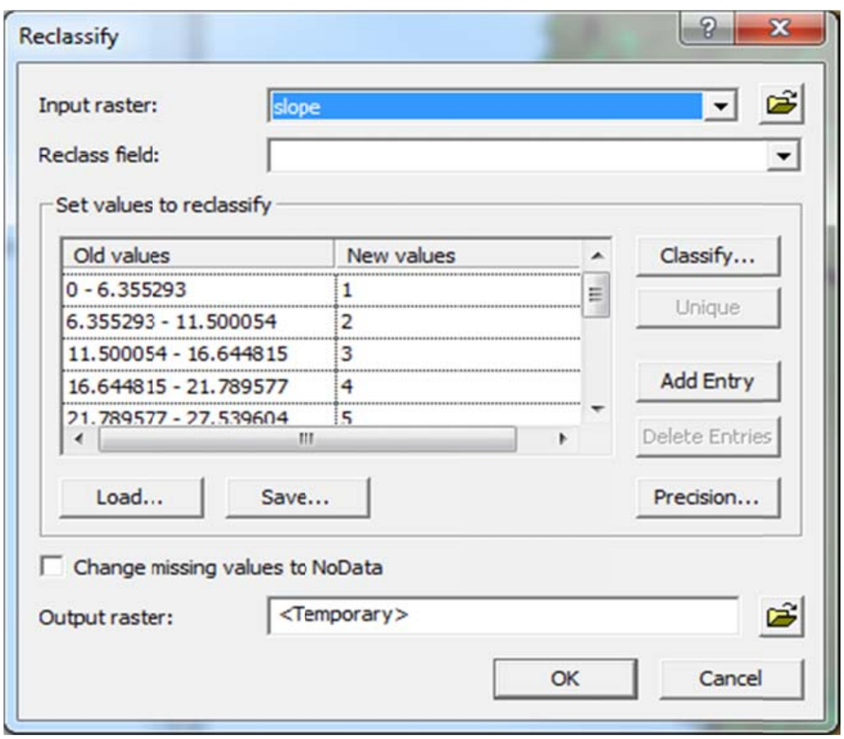


Figure 12: Window showing slope values to be reclassified into four classes.

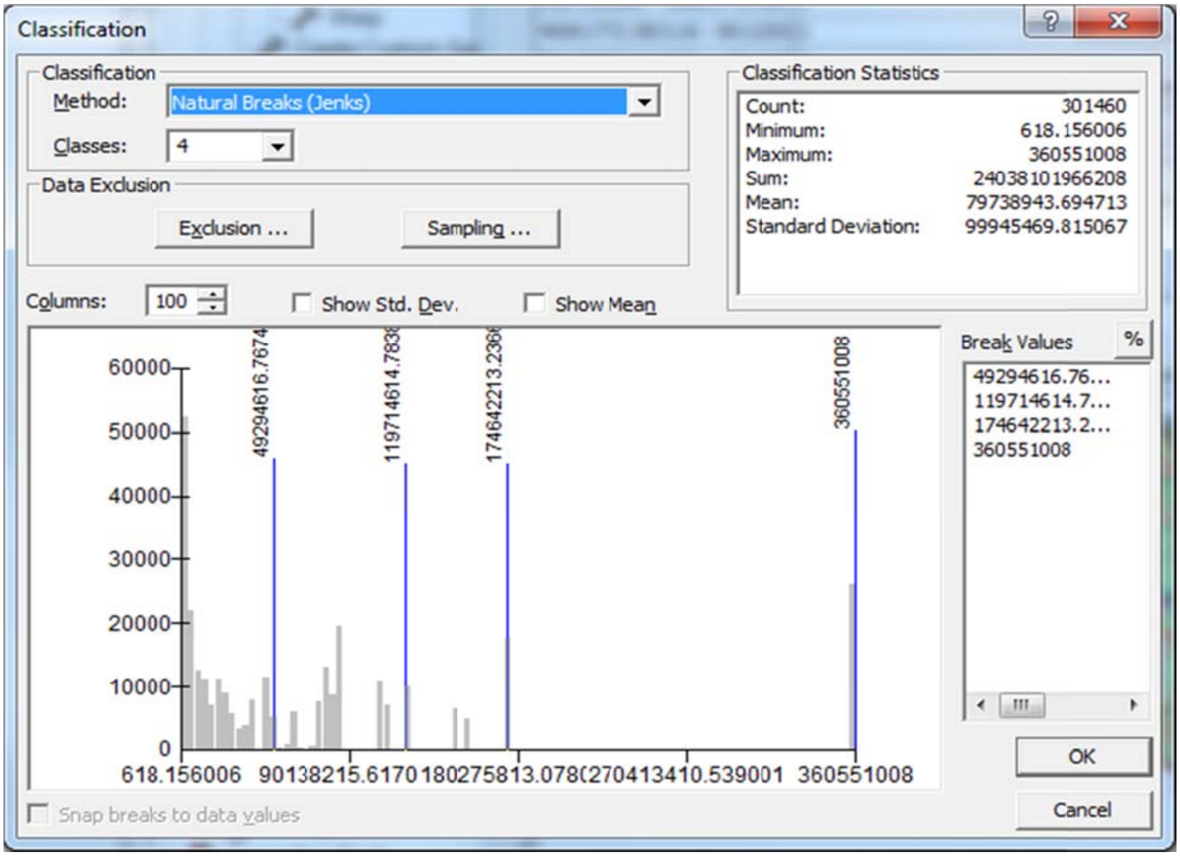


Figure 13: Classification window showing the different classes and classification statistics.

Combining data sets:

I will be treating each of the three factors equally, so no weighting will be used. To combine the ranked data sets and produce a composite ranking layer, I used the spatial analyst toolbar and from the dropdown menu, I selected the Raster Calculator. By double-clicking on one of the ranked grids listed in the upper left column, click the plus sign, double-click on a second ranked grid, click the plus sign, double-click on a third and final ranked grid, and click Evaluate (Figure 14). I then symbolized my resulting raster output and my final raster layer is the screen capture (Figure 15) below:

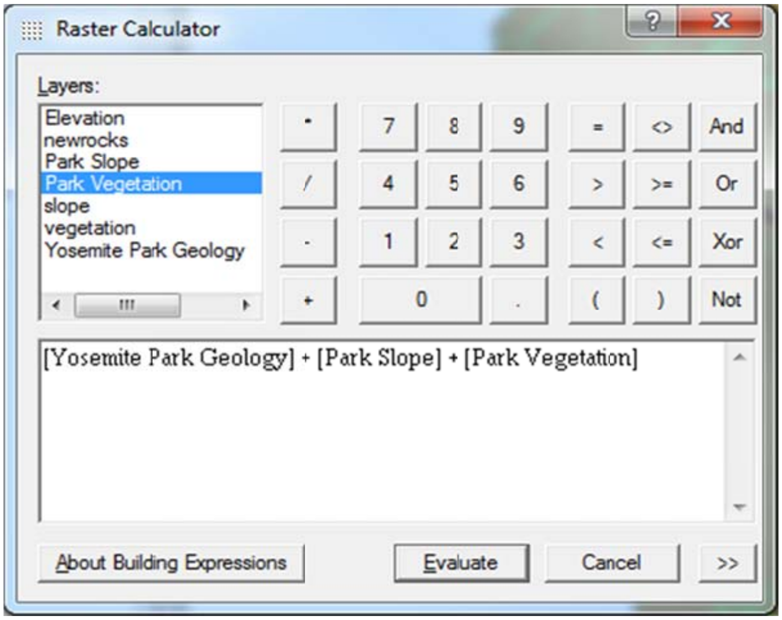


Figure 14: Window showing the raster calculator summing up the different ranked grids.

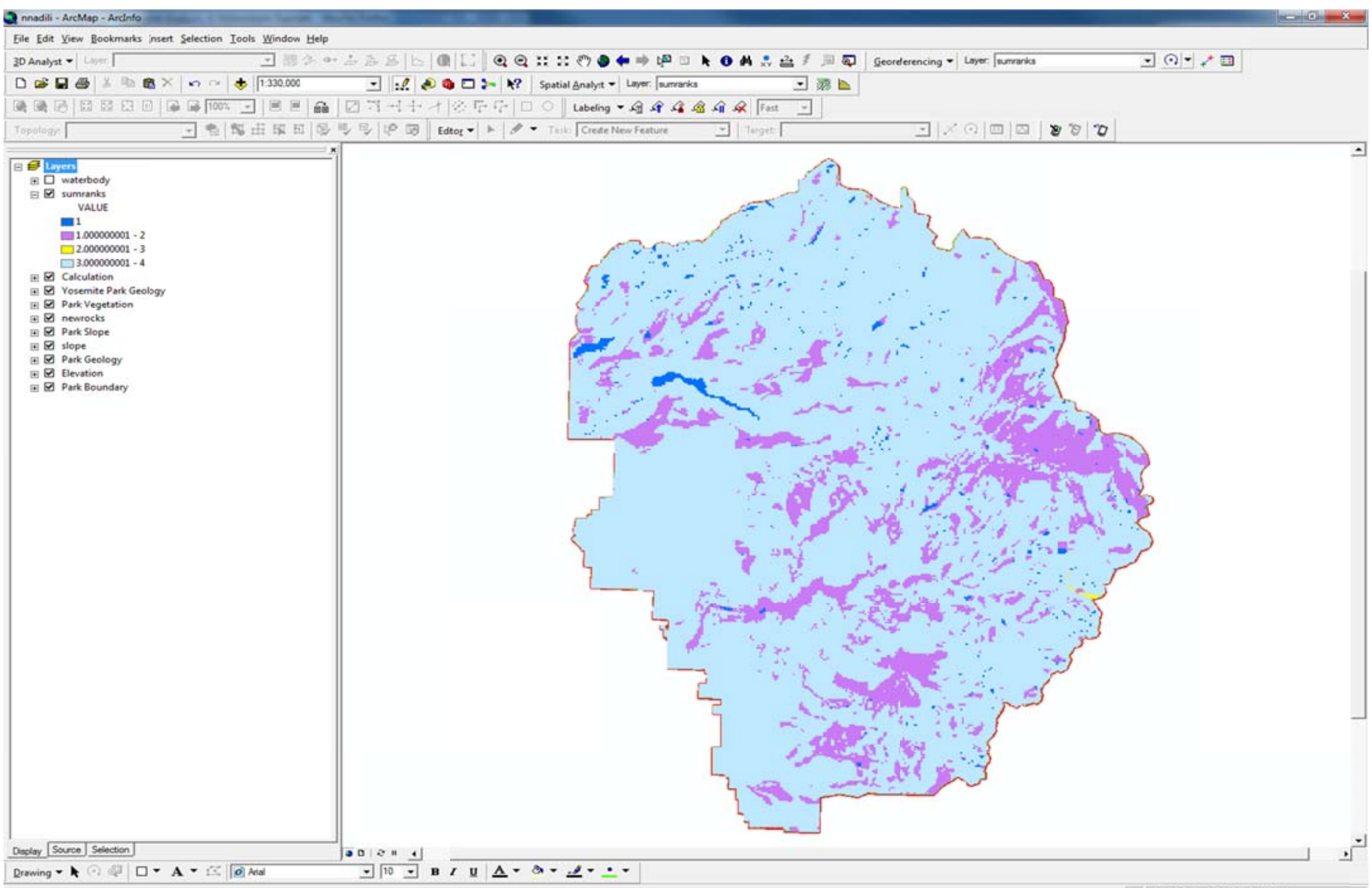


Figure 15: Raster Map of Yosemite National Park showing the four different color ramp that follows the ranking scheme developed

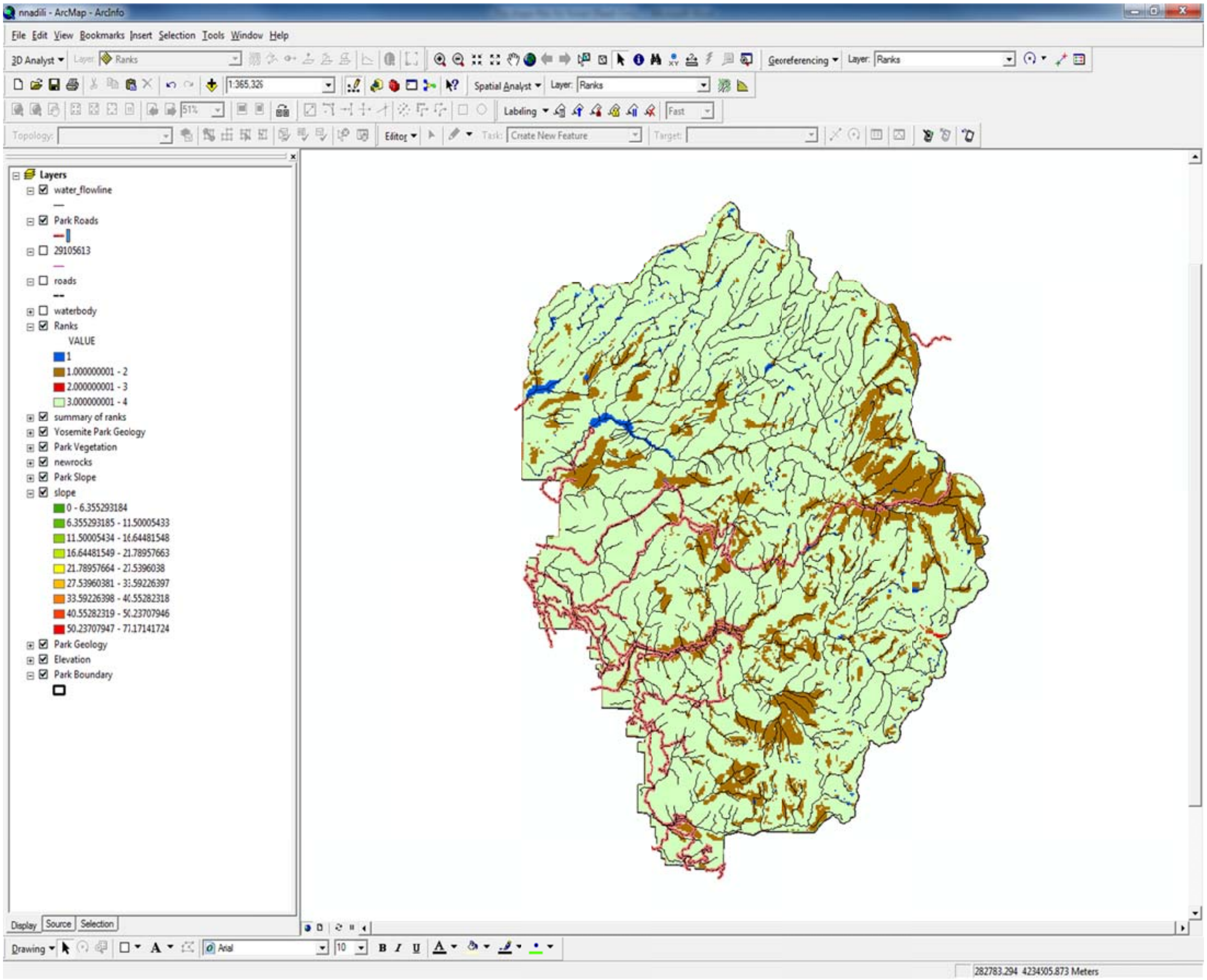


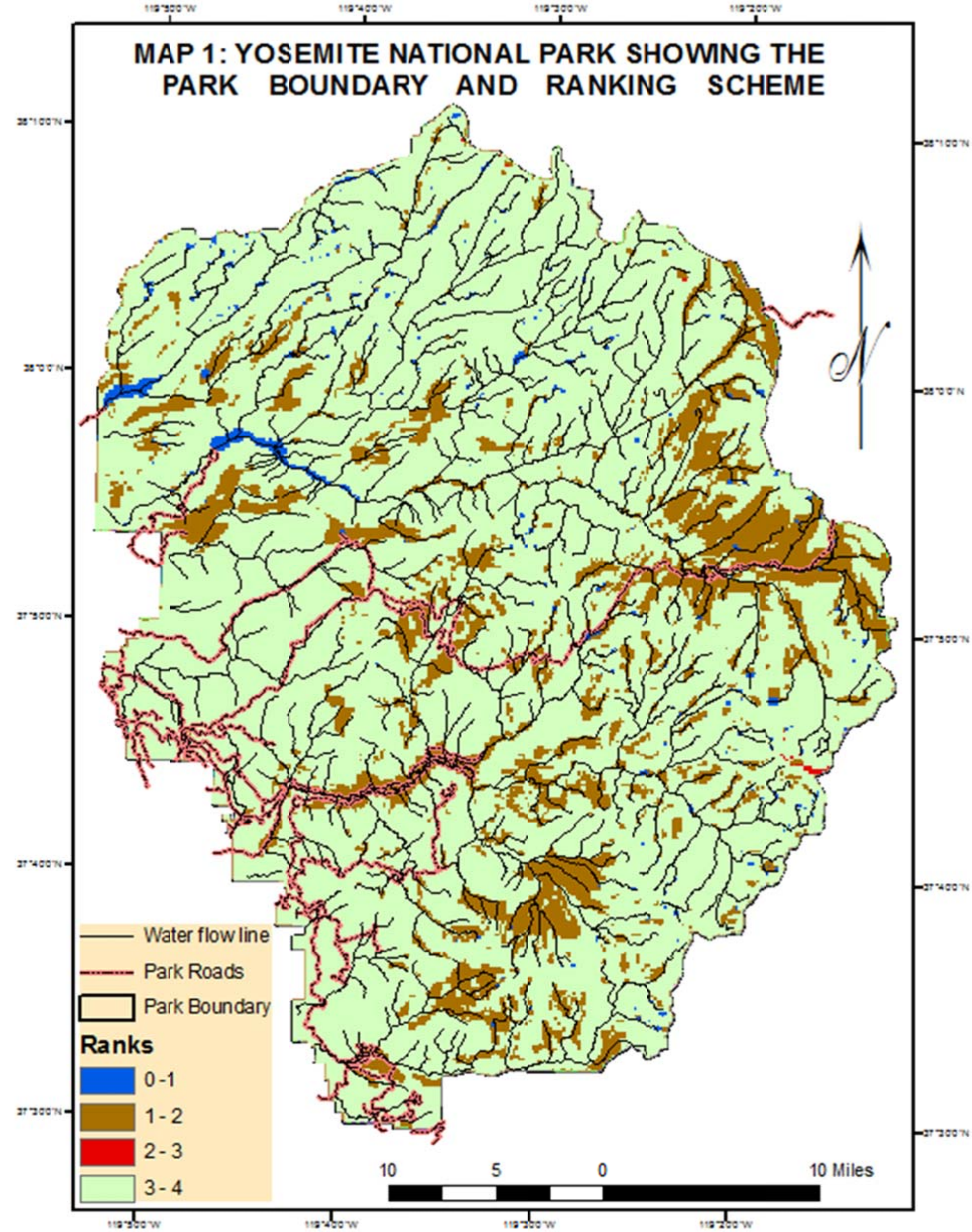
Figure 16: Raster Map of Yosemite National Park showing the four different color ramp that follows the ranking scheme developed and water flow lines.

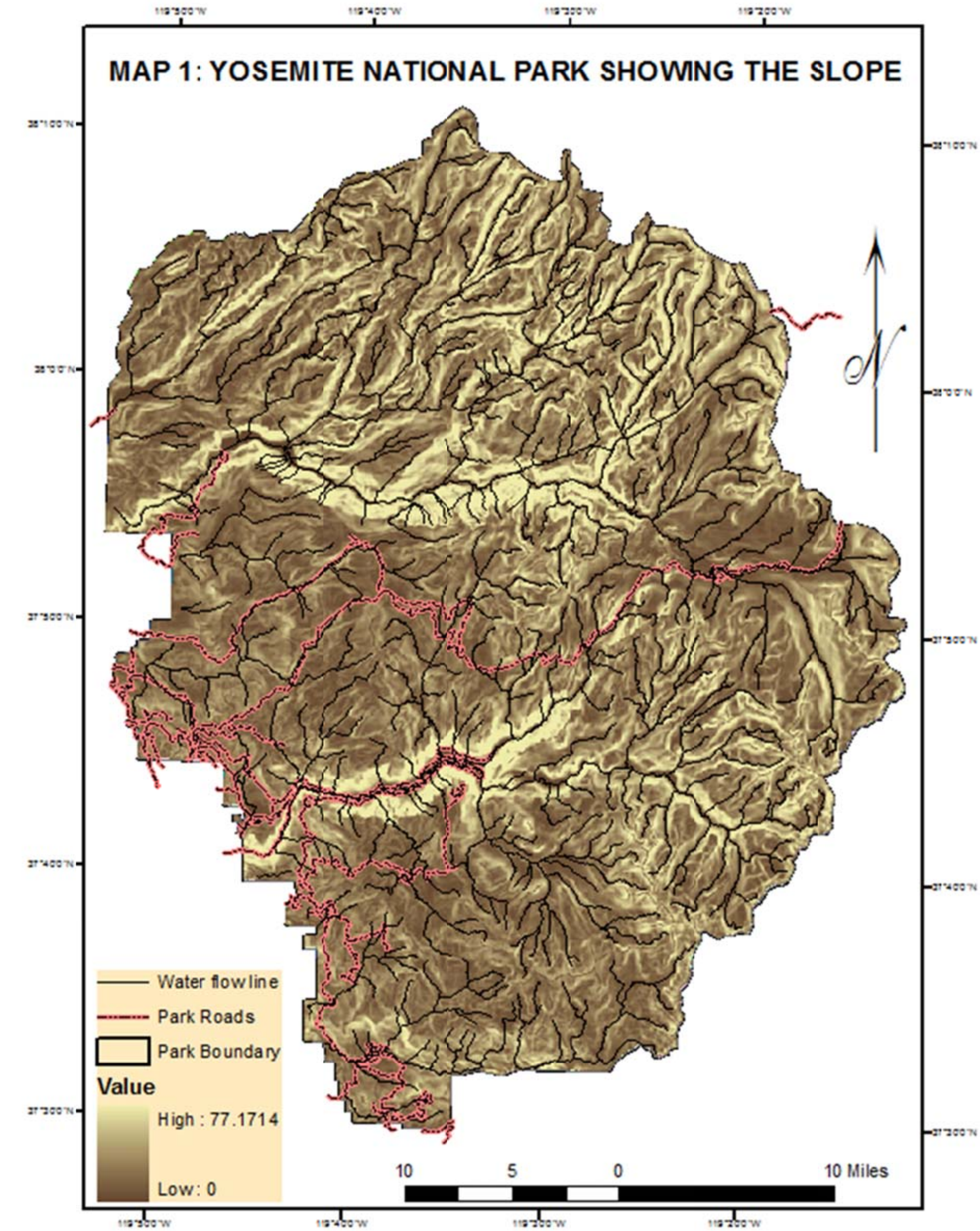
Discussions / Conclusions

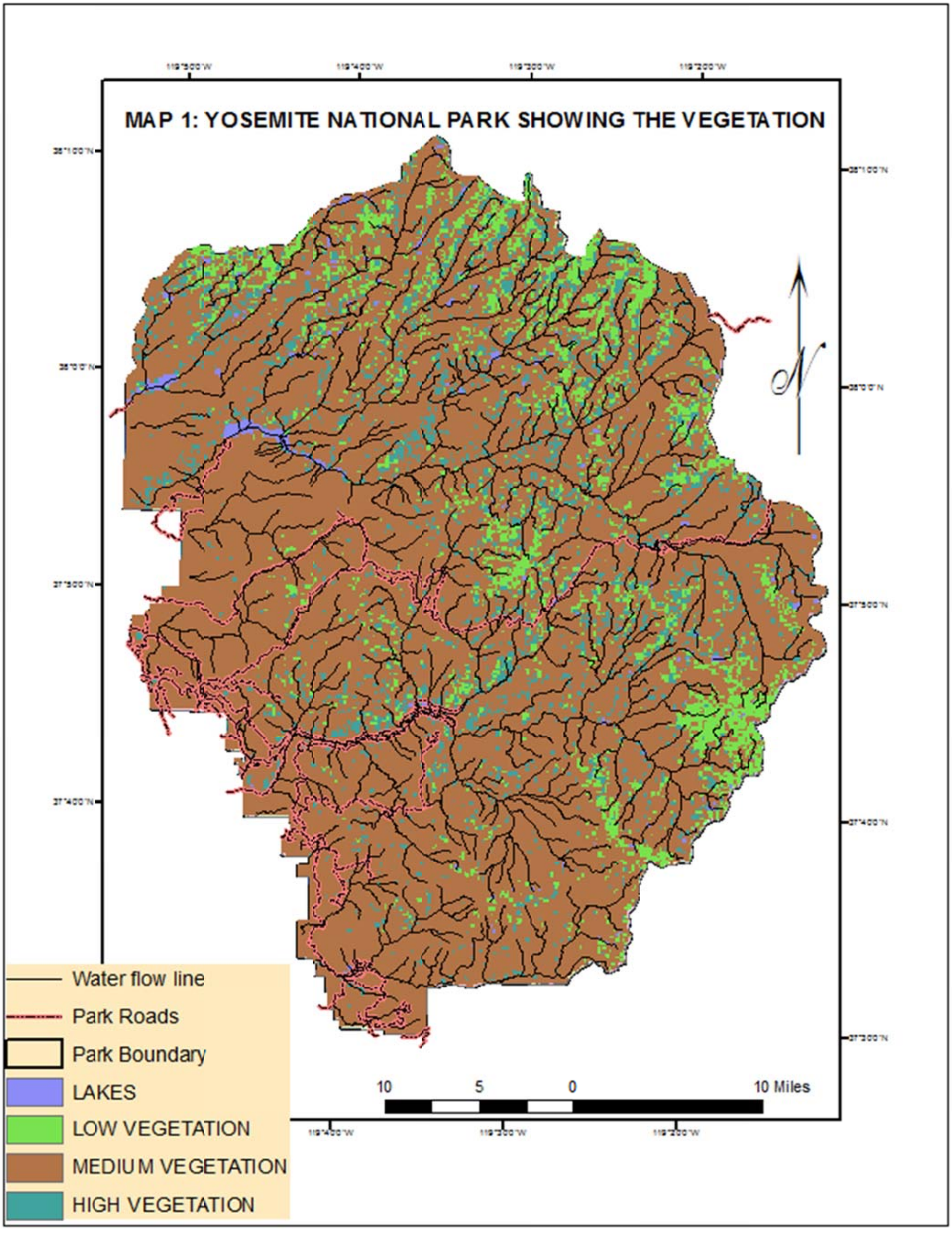
The map generation portion of this project took information from various GIS data available to get the area covered by the Yosemite National Park. The analysis portion of this project took a look at the different rock types, elevation, vegetation and water flow line to determine the areas that area prone to landslide.

Based on the analysis performed during this research, it is evident that the potential for landslide in this area is not high although various factors was ignored during this analysis, such as morphological factors (slope angle, vegetation change, erosion, uplift, rebound), physical factors (rainfall, snow melt, earthquake, ground water changes, surface runoff, seismic activity) and some geologic factors, this was due to the time limitation and challenges faced in trying to get some of the data for this analysis.

Finally, it can be concluded from the Figure 16 that areas in brown are most likely to be brown to landslide, this result was drawn as a result of the low vegetation and soft rocks present in this area. Also the presence of multiple water flow line in this area can result to landslide and Yosemite is known for its high amount of snowmelt (waterfall).


MAP 1: YOSEMITE NATIONAL PARK SHOWING THE PARK BOUNDARY AND RANKING SCHEME
Water flow line
Park Roads
Park Boundary
Ranks
0 - 1
1 - 2
2 - 3
3 - 4
10
5
0
10 Miles
N


MAP 1: YOSEMITE NATIONAL PARK SHOWING THE SLOPE
N
Water flow line
Park Roads
Park Boundary
Value
High : 77.1714
Low: 0
10
5
0
10 Miles


MAP 1: YOSEMITE NATIONAL PARK SHOWING THE VEGETATION
N
10
5
0
10 Miles
Water flow line
Park Roads
Park Boundary
LAKES
LOW VEGETATION
MEDIUM VEGETATION
HIGH VEGETATION