CE 394K/CEE6440 GIS in Water Resources Fall 2016
Final Exam Solution

3. GIS Analysis of Canyon Lake

Figure 1 on the next page shows Canyon Lake, a large reservoir located in the upper reaches of the Guadalupe Basin in Texas. A polygon of the lake boundary was created in 2000 during a hydrographic survey of the lake bathymetry made by the Texas Water Development Board[1]. This polygon can be found at:
http://www.caee.utexas.edu/prof/maidment/giswr2016/exam/CanyonLake.zip

Please do the following analysis which contains six parts. When you respond to each part, besides providing the answers to the questions posed, please briefly explain how you arrived at these answers.

(1) The (Latitude, Longitude) coordinates of the outlet of Canyon Lake at the dam in decimal degrees are (29.869001, -98.198014) in the NAD83 geographic coordinate system. Convert these coordinates to degrees, minutes and seconds. Create a point feature at the outlet of the dam and delineate its watershed using the ESRI hydro services with the Finest data resolution. What is the drainage area of this watershed (Km^2)?

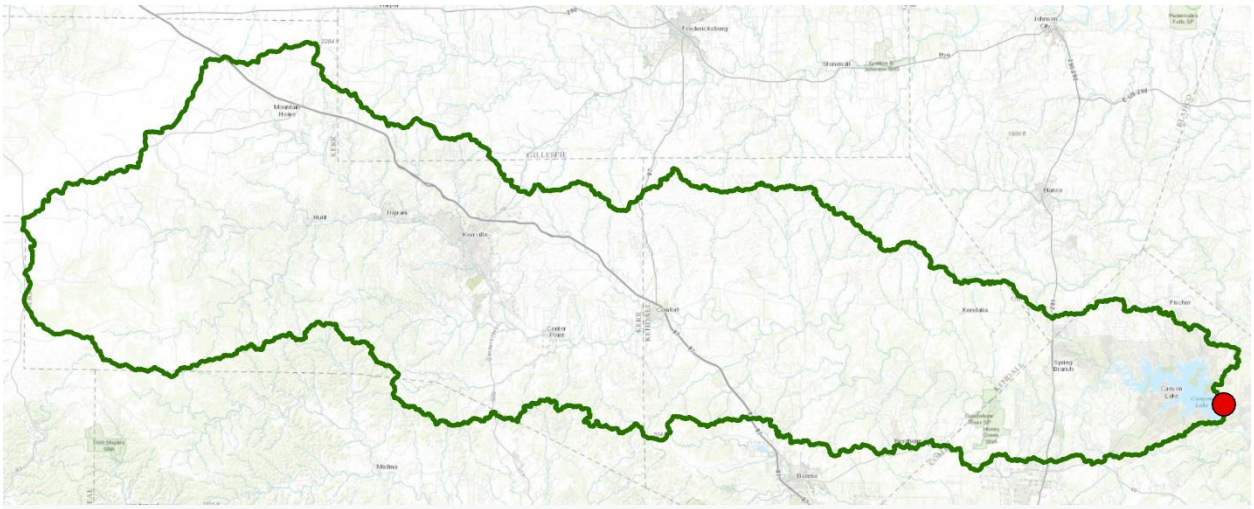
Solution: The lat-long points in decimal degrees are entered into spreadsheet and converted:

DDLat	DDLong	DegLat	MinLat	SecLat	DegLong	MinLong	SecLong	CheckLat	CheckLong
29.869001	-98.198014	29.00	52.00	8.40	98.00	11.00	52.85	29.869001	-98.198014

The outlet is at (29° 52’ 8.40” N, 98° 11’ 52.85” E). This point is located at the dam outlet

And when the ESRI Hydro services with FINEST or 30m cell resolution are used to compute the drainage area, it is found to be **3710.45 Km^2**.

[1] Canyon Lake Survey Data can be obtained at:
http://www.twdb.texas.gov/surfacewater/surveys/completed/list/index.asp



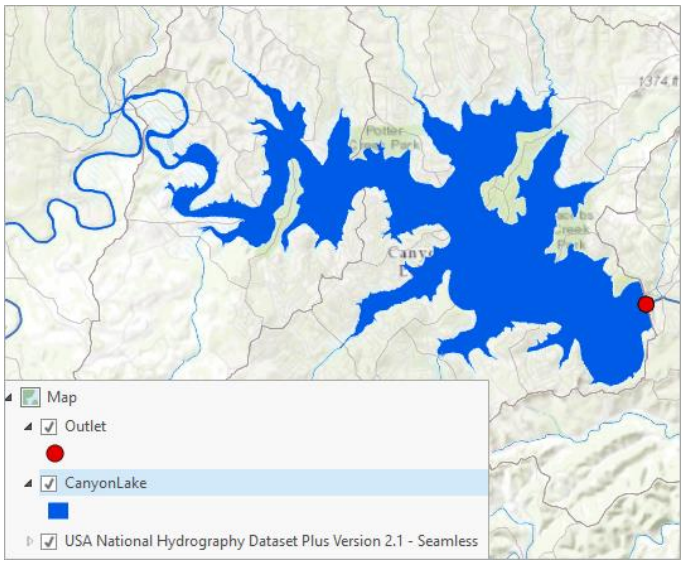
Watershed

Field: New Delete Calculate | Selection: Zoom To Switch Clear Delete

OBJECTID	Shape	Pour Point ID	Description	Data Resolutior	Area Square Kilometers	Shape_Length	Shape_Area
1	Polygon	1	NED 30m processed...	30.0	3710.4561	5.654304	0.346889

Click to add new row.

(2) The Canyon Lake shape file is in geographic coordinates using the NAD83 datum. Project this to an Albers Equal Area projection and state which projection parameters you have used. Determine the area of Canyon Lake (Km^2). What percentage of the watershed area is occupied by the lake?



Canyon Lake

Figure 1. Canyon Lake

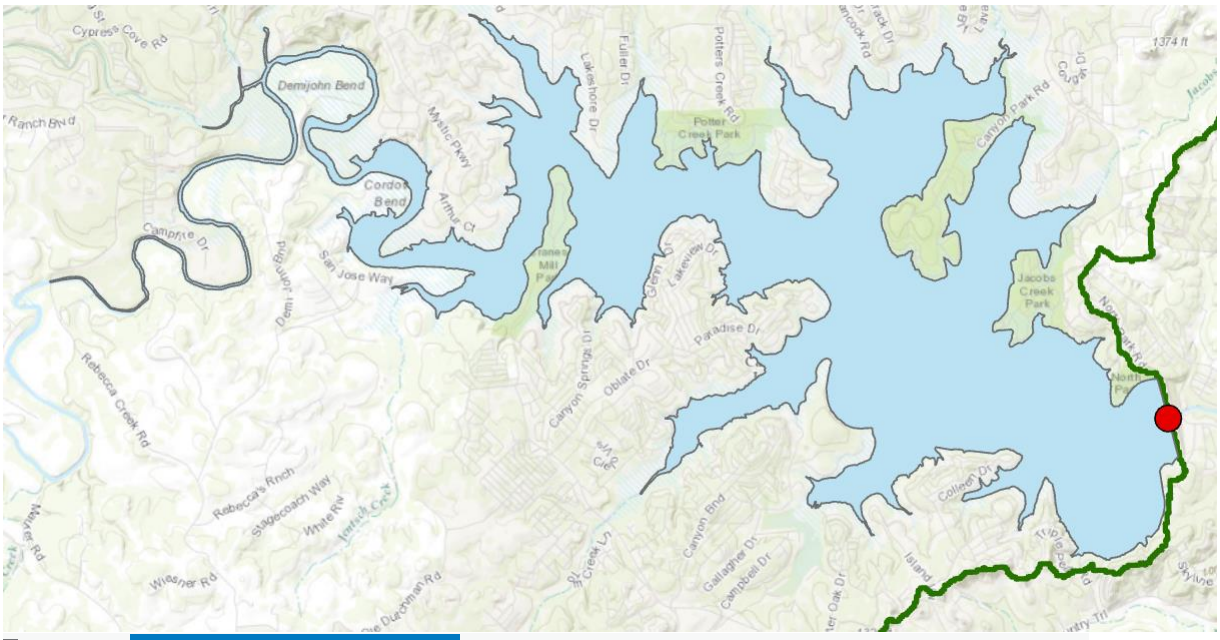
Solution:

The Canyon Lake shapefile was downloaded and projected into a feature dataset having the NAD83 Contiguous USA Albers projection whose parameters are shown below.

Spatial Reference

Projected Coordinate System	NAD 1983 Contiguous USA Albers
Projection	Albers
WKID	5070
Authority	EPSG
Linear Unit	Meter (1.0)
False Easting	0.0
False Northing	0.0
Central Meridian	-96.0
Standard Parallel 1	29.5
Standard Parallel 2	45.5
Latitude Of Origin	23.0

Geographic coordinate system	GCS North American 1983



Map | CanyonLakeProjected

ield: New | Delete | Calculate | Selection: | Zoom To | Switch | Clear | Delet

OBJECTID	Shape	CAN_83_	CAN_83_ID	Elevation	Shape_Length	Shape_Area
1	Polygon	2	0	909	150329.657373	33825433.112845
Click to add new row.						

The map units are in meters and the ShapeArea of the projected lake polygon is 33825433 m^2, or **33.825 Km^2**. Hence the percentage of the watershed that is occupied by the lake is (33.825/3710.45)*100 = **0.91%**

(3) In 2000, the lake survey found the volume of storage in the lake at elevation 909 ft above geodetic datum to be 378,852 acre-feet, as compared to 382,000 acre-feet at the same water surface elevation in 1972. This reduction is due to erosion in the watershed and sediment deposition in the lake. How much storage was lost during this period (acre-feet)? What depth of soil distributed over the watershed does this represent (mm)? 1 Km^2 = 247.105 acre. Is there significant soil erosion in this watershed?

Solution:
Storage lost from 1972 to 2000 = 382,000 – 378,852 = **3148 acre-ft.** Percentage loss = (3148/382,000)*100 = 0.82%

Converting to metric units, storage lost = 3148/247.105 = 12.7395 Km^2-ft = 12.3795*0.3048 Km^2-m = 3.883 Km^2-m. The area of the watershed is 3710.45 Km^2, so the volume of soil lost/area of watershed = 3.883/3710.45 m = 0.0010465 m = **1.0 mm**. This is a small depth and the percentage loss in storage of less than 1% in 28 years indicates that **soil erosion** from the watershed and deposition of sediment in the reservoir is **not a large issue** at Canyon Lake.

(4) Add "Mean Annual Rainfall" from the ESRI Living Atlas to your map. The units are inches of rainfall per year. Extract the mean annual rainfall coverage for the Canyon Lake watershed, as shown in Figure 2. What is the mean annual rainfall over the watershed (inches)? If 20% of this rainfall becomes flow into Canyon Lake, and there was no evaporation from the lake, how many months would it take to fill the lake from empty to elevation 909 ft above geodetic datum, given the bathymetry of the lake as measured in 2000?

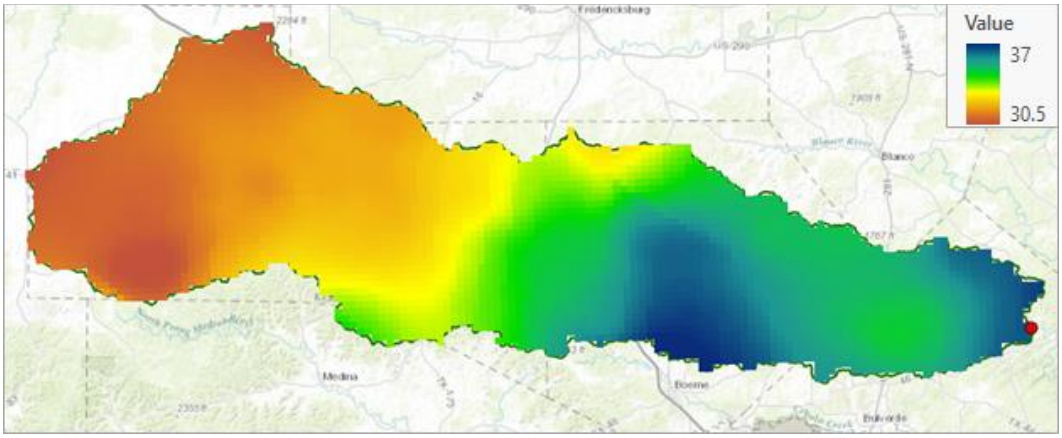


Figure 2. Canyon Lake Watershed mean annual rainfall.

Solution:
The USA Mean Annual Rainfall grid is added to the map display from the Living Atlas, and the Mean Annual Precipitation is over the watershed is derived by using the Extract by Mask tool in

ArcGIS Pro, and displayed as shown in Figure 2. The statistics of this raster are stored in its properties table:

Band Name	Minimum	Maximum	Mean	Std. Deviation
Band_1	30.5598430633545	37.066535949707	33.5235478532282	1.80528274295768

From this, it can be read that the mean annual precipitation in the watershed is **33.52 inches**. If 20% of this precipitation becomes runoff, the runoff depth will be 33.52*0.2 = 6.70 inches/yr = 0.5587 ft/yr. Now the area of the watershed is 3710.45 Km^2 = 3710.45*247.105 acres = 916870 acres. Hence the volume of runoff = 916870 * 0.5587 acre-ft/yr = 512225 acre-ft/yr. In 2000 the volume of the lake was 378,852 acre-feet, so the time it would take to fill this reservoir from empty is 378852/512225 yr = 0.7396 yr, = **8.875 months**

(5) Load the USA NLCD 2006 land cover map from the ESRI Living Atlas. Extract the land cover of the Canyon Lake watershed. Find the percentage of the land cover in each of the major land cover classes shown in Figure 3.

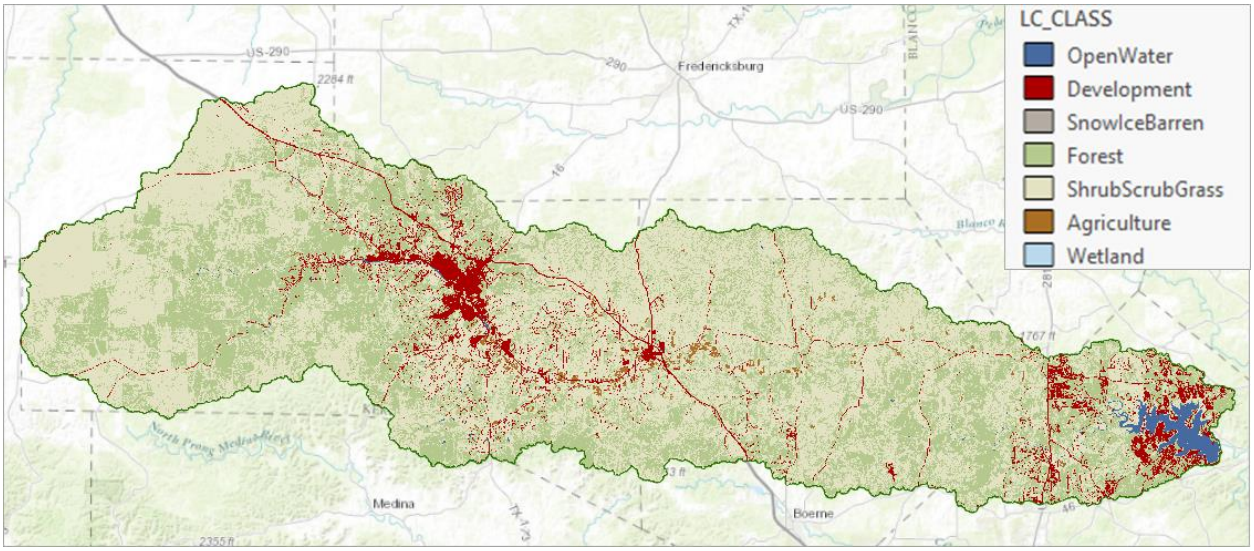


Figure 3. Canyon Lake Watershed Land Cover

Solution:

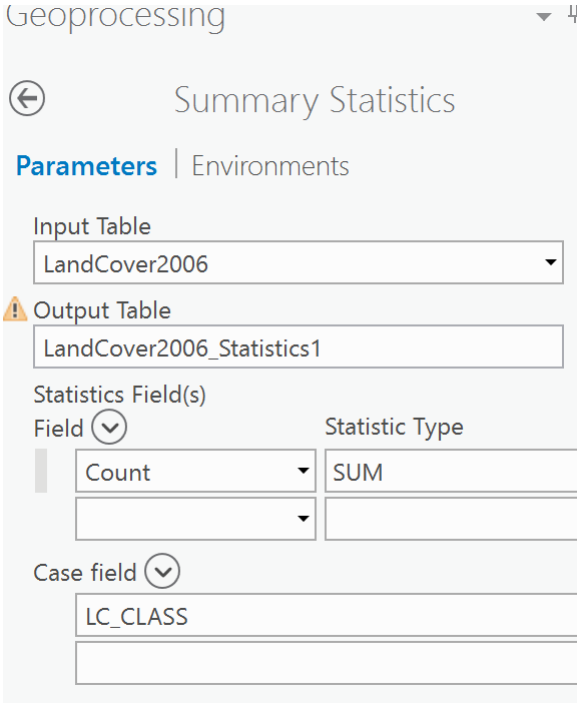
The USA NLCD 2006 land cover map is added to the display and Extract by Mask used to find the land cover over the watershed. The attribute table of this watershed land cover dataset is:

LandCover2006

Field: New Delete Calculate | Selection: Zoom To Switch Clear Delete

OBJECTID_1	OBJECTID	Value	Red	Green	Blue	Opacity	Count	LC_CLASS
1	2	11	0.28	0.42	0.63	1	59516	OpenWater
3	4	21	0.87	0.79	0.79	1	279157	Development
4	5	22	0.85	0.58	0.51	1	46200	Development
5	6	23	0.93	0	0	1	11114	Development
6	7	24	0.67	0	0	1	3668	Development
7	8	31	0.7	0.68	0.64	1	3240	SnowIceBarren
8	9	41	0.41	0.67	0.39	1	379980	Forest
9	10	42	0.11	0.39	0.19	1	1639942	Forest
10	11	43	0.71	0.79	0.56	1	852	Forest
11	12	52	0.8	0.73	0.49	1	2543846	ShrubScrubGrass
12	13	71	0.89	0.89	0.76	1	505054	ShrubScrubGrass
13	14	81	0.86	0.85	0.24	1	18245	Agriculture
14	15	82	0.67	0.44	0.16	1	21921	Agriculture
15	16	90	0.73	0.85	0.92	1	2102	Wetland

The Summary Statistics of this table are computed using the Summary Statistics function



And the result comes out to be:

LandCover2006 | LandCover2006_Statistics1

Field: New Delete Calculate | Selection: Zoom To

OBJECTID	LC_CLASS	FREQUENCY	SUM_Count
1	Agriculture	2	40166
2	Development	4	340139
3	Forest	3	2020774
4	OpenWater	1	59516
5	ShrubScrubGrass	2	3048900
6	SnowIceBarren	1	3240
7	Wetland	1	2102

Click to add new row.

These data are converted to Excel and the percent distribution computed for each Land Cover class:

LC_Class	**Count**	**Percent**
Open Water	59516	1.08
Development	340139	6.17
SnowIceBarren	3240	0.06
Forest	2020774	36.64
ShrubScrubGrass	3048900	55.29
Agriculture	40166	0.73
Wetland	2012	0.04
Total	**5514747**	**100.00**

Percent of Total Area
1.08
6.17
0.06
36.64
55.29
0.73
0.04

It can be seen that about half of the land cover is Shrub, Scrub and Grass (Land cover class 52 is Shrub and Scrub, Land cover class 71 is Grass), about a third is forest and small amounts of development and open water. There is very little agriculture so the soils are stable and this helps to reduce erosion. The total water area (1.08%) is little larger than for Canyon Lake by itself (0.9% computed earlier). This shows the role of farm ponds for water supply in this arid area of Texas.

(6) Load a national hydrography data source with mapped streams for this area (you may use any of the NHD or NHD Plus datasets you are familiar with from any source you know about or can find). Prepare a layout figure that shows mean annual rainfall as contours, land cover and

streams for the Canyon Lake watershed. Symbolize the streams in a way that larger streams stand out more than smaller streams (e.g. based on flow or area appropriately categorized). Include a title, scale bar, north arrow and legend information on the map so that it is complete and self-explanatory. This is your chance to show off your map making skills and use of GIS to present quantitative information in a complete and clear way.

Solution:

The streams are extracted for this basin from the NFIE-Geo dataset as used in Exercise 2. They are symbolized with the attribute Q1000C, the mean annual flow not adjusted for gage flows. The contours are drawn from the Mean Annual Precipitation raster using the Contour function with a contour interval of 1 inch. Here is the resulting map.