Natural Hazards and Disaster

Class 8: Lab

- Floods

Lab: Floods

Floods are the leading cause of death and property damage around the world. The most damaging floods are caused by hurricanes, typhoons, and stalled tropical storms which can drop heavy rain that lasts for several days. Coastal storm surge, including tsunami waves, often causes massive destruction to coastal communities. Flooding is also caused by rapid ice melting, which can dam rivers upstream creating lakes that subsequently break through the ice dam and swamp valleys downstream.

River flooding is often quoted in relation to a 100-year flood recurrence. This is often interpreted to mean that the flood of a stated magnitude has a 1 in 100 chance of occurring in any year. However, that is somewhat miss-leading. Floods are well represented by the Poisson distribution, which we discussed earlier. It does not mean that a flood of the specified magnitude will only occur every 100 years and it does not mean that a flood of that magnitude must occur every 100 years. It could happen next week, a dozen times over the next years, or not at all for 20 years.

The probability of flooding is based on past historical records. The 100-year flood recurrence datum will change if the frequency of flood recurrence changes significantly.

Lab: Floods

Discharge *Q* is the volume of water with time that passes a particular marker, usually the same location as the stage measurements, such as a bridge. Discharge is given in m^3/s. It is calculated from the width W and height) of the river channel and the average water velocity *V* at the measurement point:

$$Q = W \times H \times V$$

For example, a river channel with width of 3.2 m, height of 1.8 m, and average water velocity of 4.0 m/s will have a discharge Q of 3.2 x 1.8 x 4 = 23 m^3/s.

Question: The largest flood known is the Kuray ice-dam failure, which had a peak discharge of 18,000,000 m^3/s. If at a certain location the average depths was 30 m and the average velocity 30 m/s, what must have been the average width of this flood? Answer: ____________

Question: One of the largest meteorological flood took place in 1953 in the Amazon basin, with a peak discharge of 370,000 m^3/s. If at a certain location the average depths was 10 m and the average width was 3 km, what was the average velocity at this location? Answer: ______________

Lab: Floods

A substantial amount of historical data from previous flooding is needed to determine the recurrence interval of river floods. The river's 'stage' is its surface height H above a fixed point, measured by using a gauge. Observation of a river's stage over time leads to a "normal" stage for that river at that location, and flooding is generally recorded in meters or feet above the normal stage.

If the discharge rate increases, perhaps due to increased storm-water run-off, and the river valley's width cannot change, then the stage (H) must increase and the river will likely overflow its banks. Similarly, if the water continues to travel at the same velocity but becomes funneled downstream into a narrower river valley or culvert, then the stage must increase to accommodate the volume of water and flooding can result.

Lab: Exercises

On the following slides, three exercises are defined. Please, submit these exercises to me by as part of Question Set 6 by November 2, 2018.

The total number of points you can get for the exercises and answering the questions is 150. If you achieve more than 100 Points, the points above 100 will be counted as extra credits.

Lab: Floods

The flooding recurrence interval R is calculated from

$$R = \frac{(N+1)}{M}$$

where N is the number of years in the record, and M is the ranked order of the flood discharge, from greatest to least (see table below). Several years of maximum flood discharge data are required for this calculation to be meaningful.

From the sample data, the recurrence interval for a flood discharge of 6,000 m^3/s (ranked #3) or more is given by:

$$R = \frac{(114+1)}{3} = 38.33 \text{ years}$$

Thus a discharge rate of 6,000 m^3/s (or more) could be considered to be a 38-year flood. However, it is important to note that the time intervals for the three highest flood years (1920, 1936, 2004) are not equally spaced at 38.33 years apart. Moreover, having only three events is a poor basis to compute the recurrence interval.

Table 1. Sample Discharge Table
Discharge rates are ranked in order of the magnitude of discharge. The period of analysis for this hypothetical sample set is 114 years (from 1902 to 2016).

Month	Year	Discharge (m^3/s)	Rank order
January	1936	8,500	1
December	2004	6,400	2
February	1920	6,000	3
January	1958	4,600	4
March	1983	2,900	5
January	2006	2,800	6
March	1939	2,500	7
November	1902	2,000	8

River discharge data is usually listed along with the month and/or year of measurement.

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Flood recurrence interval is not the same as probability of flooding. The probability p of a flood of a specified discharge rate in any given year is given by:

$$p = 1/R$$

In the example, the probability of a flood with discharge rate of 6,000 m^3/s or more in a given year is:

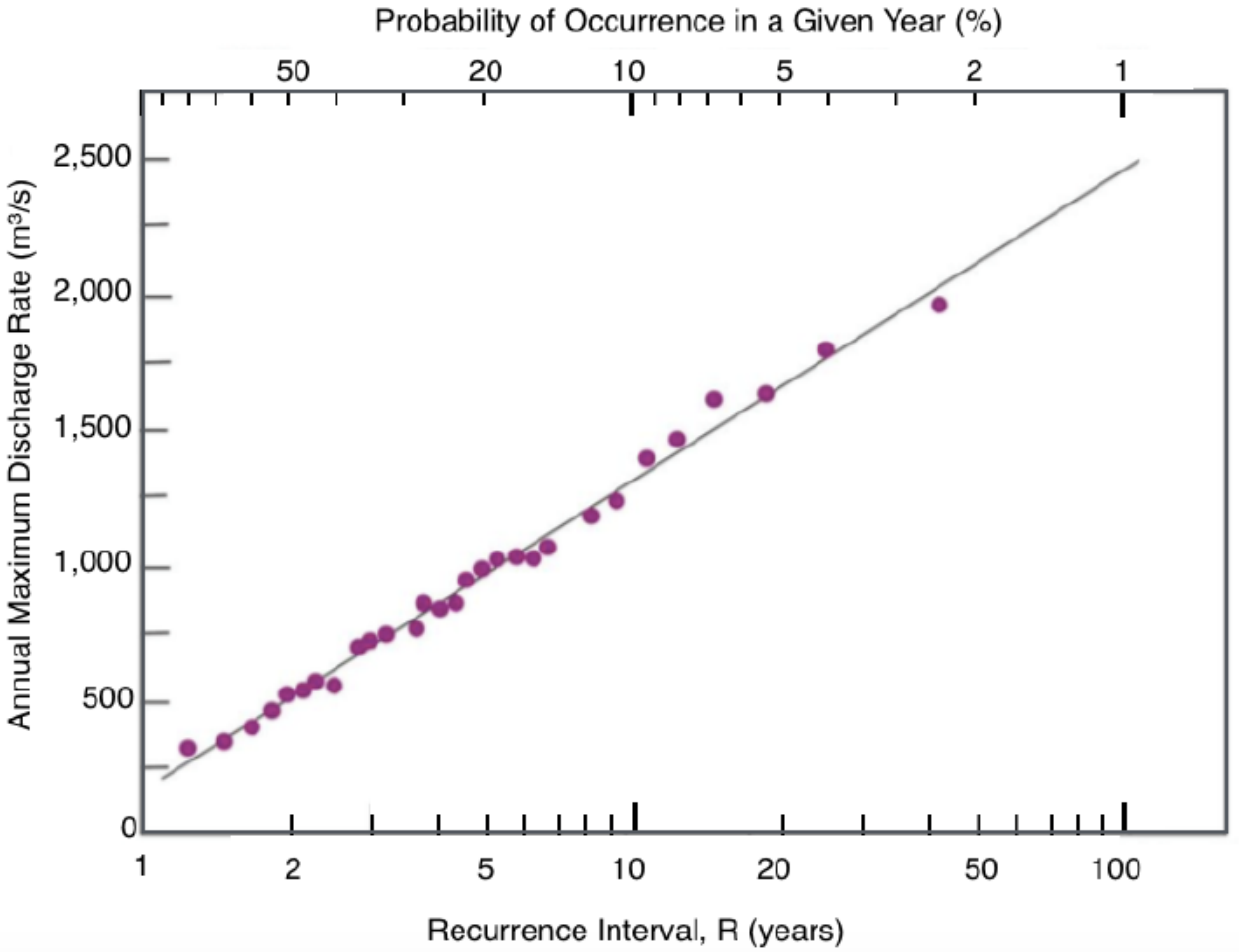
p = 1/38.33 = 0.026 or 2.6%

Exercise 1: Using the sample data in Table 1, calculate the percent probability of a flood with a discharge rate of 2,900 m^3/s or larger.

p =______________%

Points: 20

Of course, real floods do not occur with simple, round number discharge rates. If there are sufficient available historical data, a probability graph can be useful. The recorded discharge rate *Q* is plotted against *R*, the recurrence interval. *Q* is plotted on a linear scale but both *R* and *p* are plotted on log scales (this is called a semi-log plot). A trend line analysis, which is the line of best fit through the data, allows the probability of any discharge volume occurrence in a given year to be read from the graph. Smaller volume floods naturally occur more frequently than very large discharge volume floods and so the trend line, and therefore the probability prediction, is much more accurate for small volume floods.



Exercise 2: Using the semi-log probability graph, estimate the probability of a discharge rate of 750 m^3/s and 1,600 m^3/s, respectively, in any given year.

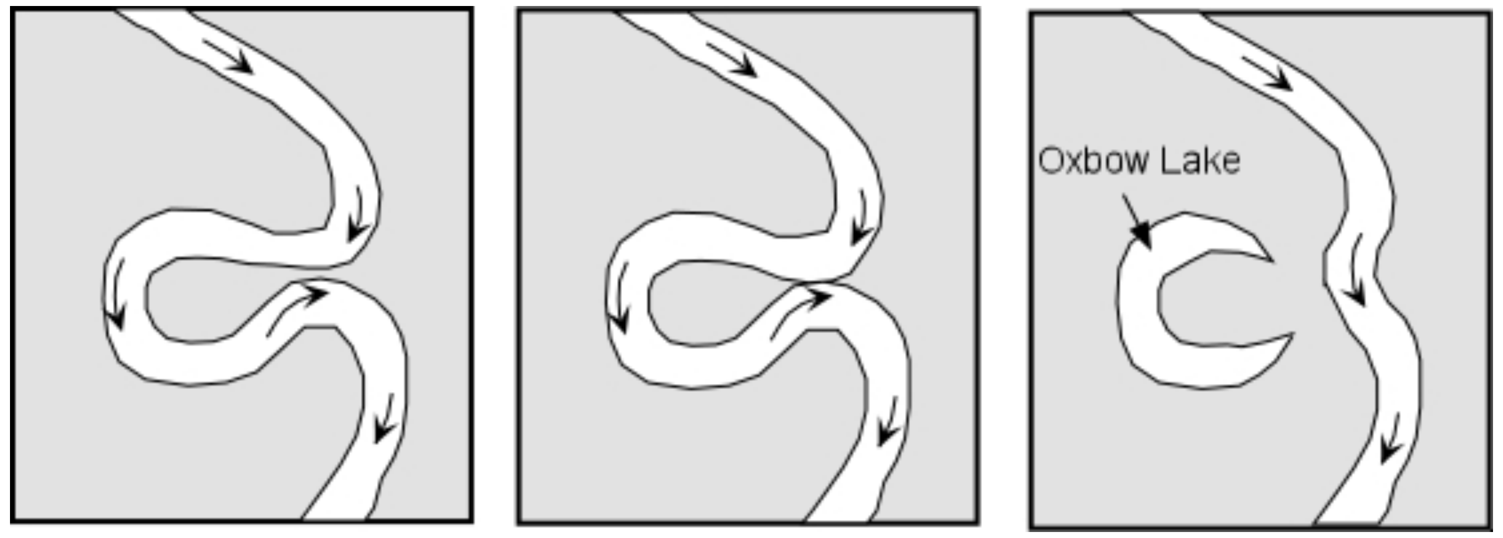
Points: 20

Graph shows 50 years of annual maximum discharge rate data measured at the same point on a river, plotted against the calculated recurrence interval.

Exercise 4. Meander cut-offs by flooding events

The geological map on the next page was created in 1944 for the Office of the President's Mississippi River Commission. It shows the different meanders (curves) that the Mississippi River made over time along this section of its length. Each meander became abandoned as an ox-bow lake during a flood event, when the river broke across the narrowest part of the loop to take a more direct route to the ocean.

Over time, the river gradually carved out new meanders and deposited new sediments in its river bed on the outermost banks of the meanders.



The Legend on the right of the map below shows the relative ages of each abandoned meander. Information about their relative ages comes from the age of the sediments deposited within the meander cut-offs. Where the ages cannot be determined with precision, it is still possible to tell which is the younger of two abandoned ox-bow meanders by looking at the superposition of sediments, such as gravels which indicate fast-moving water deposited on top of muds, which indicate slow-moving or still water.

For this exercise, print out the map, carry out the exercises indicated on the next slide, scan the map or take a picture, and include the picture of the completed map in your submission.

A. Examine the map and using a green pencil trace out the path that the river took in 1880 (unit #19, light green color at top of the legend list).

B. Now use a red pencil to trace out the path of the river before the 1880 segments were deposited (dark red, unit #18)

C. Identify and clearly label where the river at the time unit #19 sediments were deposited must have abandoned a meander filled with sediments of unit #18. This abandoned meander would have been an ox-bow lake when the river flow was cut-off.

D. Identify and trace out units #8 and #9 (light pink) as far as you can. Are there any abandoned meanders in these units? If so, locate them and label them on the map.

E. Two small towns, Hayti (labeled H) and Caruthersville (C) are situated on the Missouri side of the river, near the top edge of the map. You can see them on GoogleEarth if you zoom in to Lat 36.21°N, Lon -89.7°W. What would you advise the officials of these two towns (if you were asked) about the wisdom of further property development, given the history of the Mississippi River's course in this region? What information do you think they should be aware of?

50 points

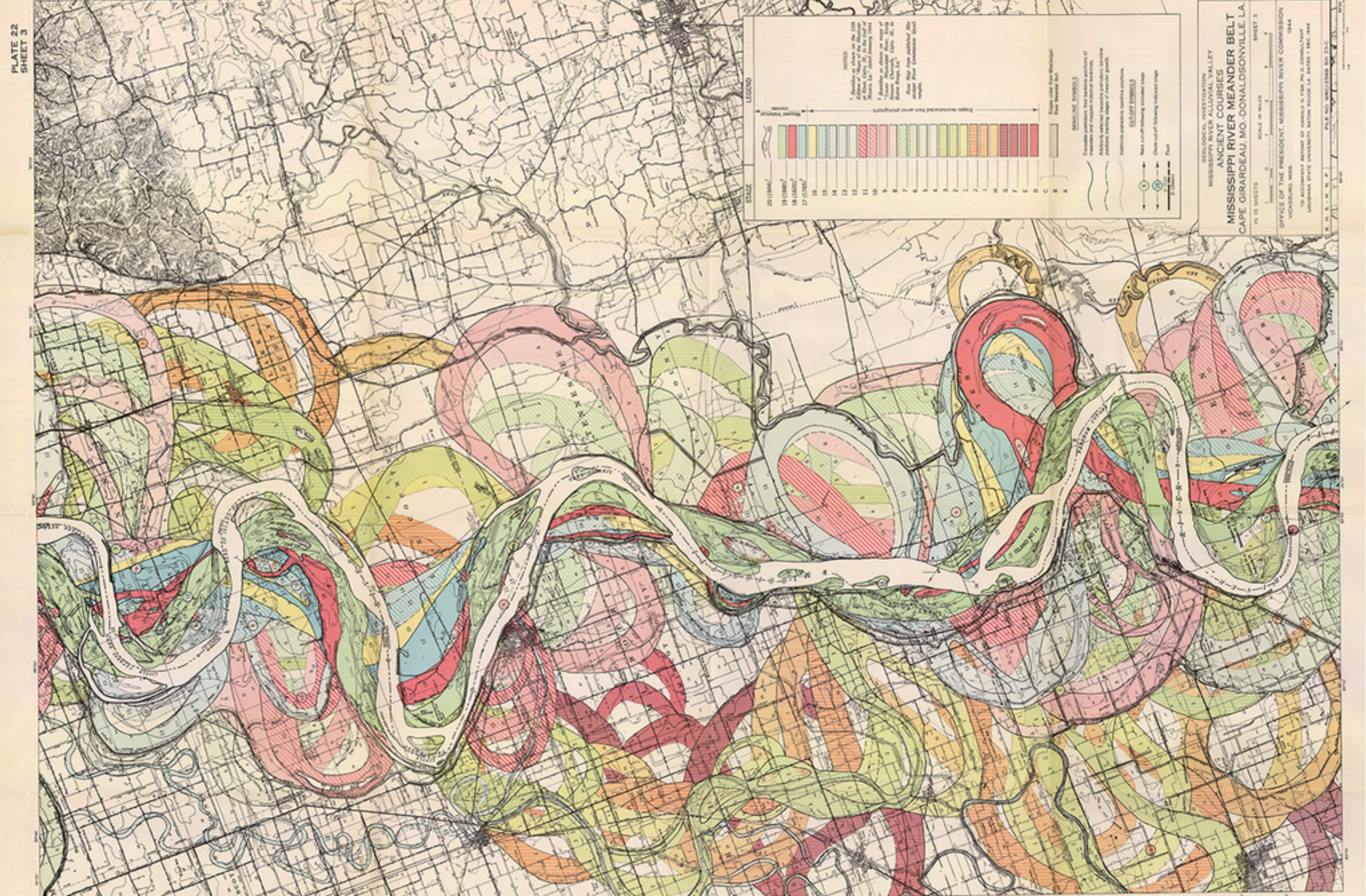


PLATE 22
SHEET 3
LEGEND
GEOLOGICAL INVESTIGATION
MISSISSIPPI RIVER ALLUVIAL VALLEY
ANCIENT COURSES
MISSISSIPPI RIVER MEANDER BELT
CAPE GIRARDEAU, MO.-DONALDSONVILLE, LA.
IN 15 SHEETS
SHEET 3
1944
OFFICE OF THE PRESIDENT, MISSISSIPPI RIVER COMMISSION
VICKSBURG, MISS.