

Is the Big Flood Due? Ranking 24 Years of River Peaks

Learning target: I can rank a river's yearly flood peaks, calculate recurrence intervals and yearly chances, graph them, and explain why a '25-year' or '100-year' flood is a probability each year, not a schedule.

Data and graphing

About 50 min

Individual

MS-ESS3-2 · assesses

data analysis

independent practice

Name

Date

Period

Directions

The river and its numbers are a teaching dataset: they were invented to behave like a real California river, but no real gauge measured them. Each number is the single highest flow the river reached in that year (its annual peak). Show every calculation, keep units on every number, and round recurrence intervals to one decimal place. Use a ruler on the graph.

You will need: This worksheet, Pencil, Ruler, Calculator, Scrap paper or 24 small slips of paper for ranking

The river record

A streamgage on Arroyo Verde, a river that runs past the town of Mission Flats, has measured flow since 2001. Flow is the volume of water passing the gage each second, in cubic meters per second (m³/s). When flow rises above 250 m³/s, the river spills over its banks onto the floodplain where part of the town is built. Like most California rivers, Arroyo Verde has its biggest peaks in winters when atmospheric rivers bring days of heavy rain, and small peaks in drought years.

Annual peak flow of Arroyo Verde at Mission Flats, 2001-2024 (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Year	Peak flow (m³/s)	Year	Peak flow (m³/s)
2001	140	2013	50
2002	95	2014	40
2003	210	2015	85
2004	120	2016	190
2005	480	2017	620
2006	360	2018	130
2007	60	2019	410
2008	230	2020	70

Year	Peak flow (m ³ /s)	Year	Peak flow (m ³ /s)
2009	110	2021	45
2010	260	2022	160
2011	300	2023	550
2012	75	2024	280

Simulated data for teaching. The pattern (wet-winter spikes, drought-year lows, big years close together) is realistic, but the river, the town and the values are invented.

How hydrologists turn a record into chances — List all the annual peaks from largest to smallest and give each a rank, m (largest = 1). With n years of record, the recurrence interval of a flood is $T = (n + 1) \div m$ years. The chance of a flood at least that big in any one year is $1 \div T$, written as a percent. Here n = 24, so n + 1 = 25. Example: the 7th largest peak has $T = 25 \div 7 = 3.6$ years and a yearly chance of $7 \div 25 = 28$ percent.

Recurrence intervals and yearly chances (real reference values)

Recurrence interval (years)	Chance in any one year
2	50%
5	20%
10	10%
25	4%
50	2%
100	1%
500	0.2%

These pairs follow from chance = $1 \div T$ and match the table the U.S. Geological Survey uses to explain flood probabilities.

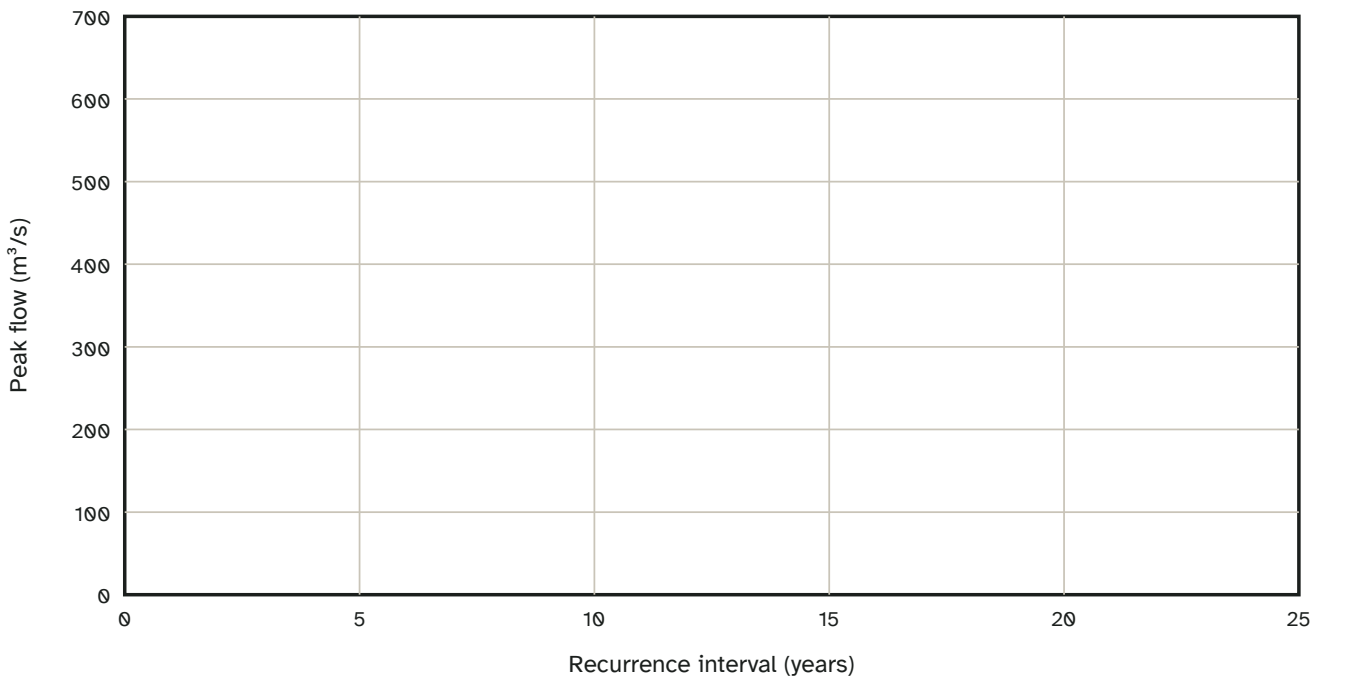
Part A: Rank and calculate

1. Rank all 24 peaks on scrap paper. Then fill in this table for the ranks shown. Show one full calculation of T and of the yearly chance below the table.

Year	Peak flow (m³/s)	Recurrence interval T = 25 ÷ m (years)	Chance in any one year (%)
Rank 1			
Rank 2			
Rank 3			
Rank 4			
Rank 5			
Rank 8			
Rank 12			
Rank 20			

2. In how many of the 24 years did the river spill onto the floodplain (flow above 250 m³/s)? Use the rank of the smallest of those floods to find the recurrence interval and yearly chance of an 'overflow year.'

Arroyo Verde: peak flow versus recurrence interval



Part B: Interpret and forecast

3. Describe the shape of your curve. What happens to the size of the flood as the recurrence interval gets longer, and is the increase steady or does it change?

4. Use your curve to estimate the peak flow of a 10-year flood on Arroyo Verde. Explain how you read it from the graph.

5. A 25-year flood has a 4 percent chance each year, so the chance of **no** 25-year flood in a year is 96 percent. (a) What is the chance of no 25-year flood in either of the next two years? (b) What is the chance of at least one in the next two years? (c) What is the chance of 25-year floods in **both** of the next two years? Show your multiplication.

6. The town wants to know the size of Arroyo Verde's 100-year flood. Why can this 24-year record not answer that question well? Name one kind of extra data that would help.

7. A resident says, 'The 2017 flood was the biggest in 24 years, a 25-year flood. So 2023 must have been a fluke, and the next flood that big won't come until about 2042.' Use the dataset and your calculations to explain what is wrong with this reasoning, and write a correct forecast statement for floods of that size.

8. Mission Flats will build a new fire station that should last 50 years. Over 50 years, the chance of at least one 25-year flood is about 87 percent, and the chance of at least one 100-year flood is about 39 percent. Recommend where or how high the station should be built, and use these numbers to justify your choice.

Ranking without getting lost

Copy the 24 flows onto 24 small slips of paper with their years, then lay the slips in a line from biggest to smallest and number them 1 to 24. For each rank in $q1$, divide 25 by the rank to get T , then divide the rank by 25 and multiply by 100 to get the yearly chance. Check: T times the chance (as a decimal) should always equal 1. For example, rank 5 gives $T = 5.0$ years and a chance of 20 percent, and $5.0 \times 0.20 = 1$.

A changing river

Suppose Mission Flats paved large areas upstream between 2010 and 2015. Explain how more runoff could make recent peaks larger than older ones even with the same storms, and why that would make the whole 24-year record less trustworthy for forecasting. Then propose how a hydrologist could check whether the river's behavior has changed, using only the dataset on this page.