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Designing for Appropriate Return Intervals of Catastrophic Events

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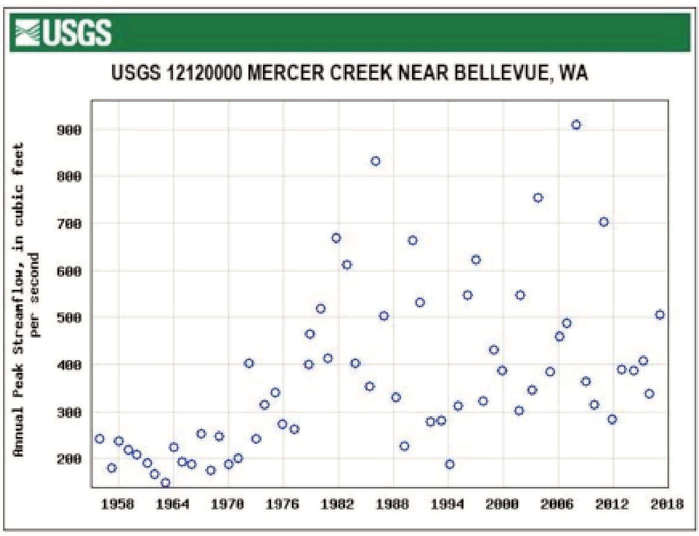
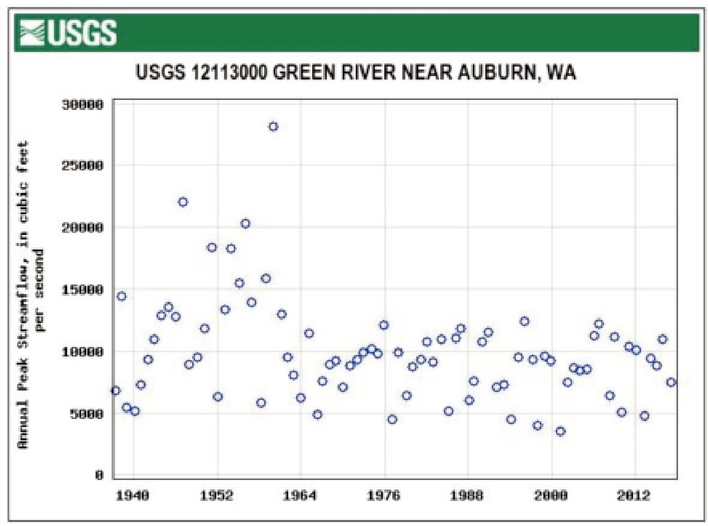


Rapid urban development in the Mercer Creek Basin since 1977 has increased the estimated magnitude of the "1-in-100 chance flood" at Bellevue, Wash.



The completion of Howard Hanson Dam on the Green River has decreased the magnitude of the "1-in-100 chance flood" at Auburn, Wash. since 1961.

Source: USGS (Public Domain)

In the past few years, our staff in both New Orleans and Houston have had to deal with tremendous flood events due to rainfall that ranked among the largest in memory. These events are sometimes referred to by their calculated return interval, such as a "100-year flood". The flooding in Houston due to rain from hurricane Harvey was said to have had a return interval of several hundred years. However, the designation of a return interval is not an indication that such an event will not happen again in the stated time period, and Houston has indeed experienced historically torrential rain and flooding in the brief period since Harvey. Our New Orleans office recently experienced historic events about six weeks apart that were probably in the 100-year return interval range. What the return interval represents is the probability that an event will happen in any given year. So, a "100-year storm" just means that there is a 1/100 or 1% chance of such an event occurring in each year. It is possible it could happen again in the next year. In fact, according to the United States Geological Survey commentary on the National Flood Insurance Program, a home with a 30-year mortgage that is in the 100-year floodplain may have a 26 percent chance of being flooded at least once during the 30-year life of the mortgage! This is due to the multiplying nature of the statistical calculations of chance. (I found statistics class at Georgia Tech mystifying. About the only practical thing I took away was that if you have a jar of bolts with one bad one in it, you need to pour them out on your bench and just look through them once because if you don't, that bad bolt is going to keep showing up every time you reach into the jar to try to get a good one.)

The volume of rain falling in a given time period is not the only factor that determines what a "100-year flood" is for a given spot on earth. Changes in the watershed, such as the construction of paved areas or buildings upstream, or the appearance of obstructions downstream, will affect how fast water concentrates at a loca-

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tion of interest. Flooding patterns change as a result, and a new return interval must be calculated for the location to take these developments into account. To allow for all conceivable future changes in the watershed affecting a given location would require an ability to predict the future, which we unfortunately cannot do. Long term trends in weather can also affect the calculation. If you moved to a spot that had never been observed and therefore had no historical data, you would have to start collecting information before you could state a return interval, and after the first year you could state what the observed "1-year flood" was for that area. If by chance a torrential rain occurred during that first year, what you might call a "1-year flood" based on your limited data string might in subsequent years turn out to have been a 50 or 100-year flood. The reverse is also true. If you had 50 years of observations at the location but it had been an extraordinarily dry period, your "50-year flood" might later be called only a 10 or 20-year flood after a full century of data had been collected. One of our former employees was working in China around World War II and needed the flood elevation of a river to design a structure. He asked the local authorities for the flood gauge readings, and they in turn asked how many years of data he wanted. He said ,"Well, let me see all you have," and they replied, "Well, we have a couple of thousand years of data". He reconsidered and said the last hundred years of data would be adequate for his purposes.

So the determination of return interval depends on the quantity and quality of the data available, the physical changes in the watershed that feed the spot you are studying, and the arcane nature of statistical calculations. (And one would do well to remember the quip of American humorist and author Mark Twain, who commented about the frustrating nature of that branch of mathematics: "There are lies, damn lies, and statistics!")

What is the practical lesson of this knowledge on how we determine the likelihood of flooding? It is that most choices in engineering design are a compromise based on economic decisions by our clients. The National Flood Insurance Program is based on a 100 year return interval flood, but the choice of that return period is just to assess what structures are eligible to be insured under that program. I have spoken with insurance agents about coverage on existing structures that did not meet the minimum elevation requirements and was told, "Look, I can find coverage for anything you want me to somewhere in the market; it's just a matter of what it's going to cost based on the risk." This revelatory statement gave me a new perspective on the insurance industry and how the design process relates to it. Our role as professional engineers is to meet the minimum design requirements of the building codes. We can try to help our clients understand the economic risks inherent in building to the minimum requirements, but many will not or cannot invest the extra money to exceed the requirements. Our clients are operating in a global marketplace where profit margins are constantly challenged. It may be desirable to design against extraordinary events affecting their facilities, but their financial survival is dependent on bringing their product to the current market at a cost that allows them to sell it at a competitive price. We will always face changing environmental and economic conditions. All we can do is meet the design code requirements for that time at that place. Going beyond that requirement is an economic decision on the part of our clients which we will happily comply with if they ask us to, but it is a rare occurrence.

There seems to be an obsession with 100-year return intervals, but there is nothing magic about this number. It was probably chosen because few humans live longer than that, so it met a time horizon beyond which most people cease to be concerned. However, there are times when much longer time intervals are chosen for design. We were involved with the development of an offshore platform complex that represented an investment of hundreds of millions of dollars and had an expected operating life of decades. Due to the size of the economic investment, the design storm conditions chosen were for a return interval of 400 years. In another instance, one of our engineers was asked to design a temple for the use of his religious order. The design criteria stated they wanted it to last 1,000 years, and as a result, stone was the only building material that met the criteria. No metal was used because it could be expected to corrode and cause failure of some sort in the thousand-year design life. When The Netherlands was devastated by flooding from a North Sea storm in the early 1950's, the loss of life and property was so great that the government decided to use a 10,000-year return interval to design their new defenses against coastal flooding. While we have not been involved with them, the facilities for storage of highly radioactive nuclear waste conceivably need to be designed for safe containment of the material for several tens of thousands of years, since the decay half-life for some of the substances is so long that they will remain hazardous to humans for many millennia.

Considering some of these longer time horizons necessitates looking at trends beyond our typical experience as humans. Sea level is said to be rising at this time in history, but it has in past epochs been much lower than current levels. We were involved with the design of an offshore platform that was in 80 feet of water about 40 miles off the coast of Louisiana, and the geotechnical engineer cautioned us to be aware of a submerged ancient riverbed from a time when sea level was much lower. He noted it might be filled with soft silt and affect the foundation of the structure or the stability of the jack-up barge used during construction. Global temperatures have been much warmer and much colder than current norms. Ice sheets hundreds of feet thick have covered areas where major cities such as New York now exist. Areas that are now cold, arid mountain regions bear fossil records of a time when they were tropical swamps.

Setting the appropriate return interval for a design is therefore an exercise in evaluating the consequences of failure given the nature of the project and the period considered necessary to perform its stated function. Most of the time, this question is addressed by meeting the minimum requirements of the applicable building code; but it can become a matter of risk analysis considering economic and life safety factors, and this frontier is where true engineering judgment becomes valuable. As our engineer decided when presented with two thousand years of flood records in China, sometimes it is reasonable to look at what we might expect in the next century or so and design for that. Other times a much longer view may be appropriate. By the end of our assumed design period, circumstances will likely have changed enough that the criteria for designing whatever comes next will be different from what we predicted anyway. Every project presents new opportunities for creative problem solving, and that is what makes engineering an interesting profession.

2019 Service Recognitions

Service recognition lunches were held honoring those with more than 20 years of service.
In the New Orleans office, the honorees were Steve Clavin (25 years), Ginger Dodge and Randal Rodrigue (30 years). In the Houston office, the honorees were Mike Harbison and Wayne Talley (30 years) and Roman Cybin (25 years).

l to r: Erin McCrossen, Steve Pumilia, Arthur Smith, Randal Rodrigue, Ken Nelson, Richie Melancon, Steve Clavin, and seated center, Ginger Nelson Dodge.

l to r: Jim Lane, Wayne Talley and David Stewart

l to r: Jim Lane, Mike Harbison and David Stewart

l to r: Bart Harris, Roman Cybin and Jim Lane

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The "Nelsoneers" from the New Orleans Office participated in the 2019 Saints Kickoff Run. Pictured l to r: Maria Azpilcueta, Jeannette Albert, Yolanda Azpilcueta, Holly Beaulieau, Lauren & Jesse Parker, Roy Phelps, Mike Delatte, Sarah Todd, Derrick Millet, Candace Wimberly, Michelle Jones, Christopher Comeaux, Luan Tran, Martin Patterson, Louis Randazzo, Tonya Coleman, Jared Nunez and Wes Bullock.