How to Operate Reservoirs

By Maddog

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Prologue

I'm writing this because I think some of it is important and some of it might be interesting. I'm not going to spend a lot of time on this, so it will be mostly based on my memory. There may be errors. It's about me by me, so it will probably say nice things about me. I've done a few things I wish I hadn't, but I won't talk about them.

I'm using pseudonyms or no names because I don't think names are important. Leo Beard will be the exception. I never met him but learned a lot from what he wrote and don't expect to say anything unflattering. I'm pretty sure I saw him in the halls of the Sacramento District when I started to work there in 1968.

I probably started working when I was about 12. I mowed lawns, shoveled snow, washed windows, painted, shined shoes, baby sat, dug ditches, was a hod carrier, sold ice cream, was a waiter, a busboy, counter man, machinist, janitor, Air Force navigator, computer programmer, hydrologist and civil engineer. I am a registered Civil Engineer in California. I worked for the U.S. Government for about 38 years. About 26 of the years were with the Sacramento District of the Corps of Engineers.

I feel lucky to have had the jobs I had. I was very interested in my jobs and still think about them often. I felt there were a lot of problems relating to the operation of reservoirs and flow frequency analysis when I left the Corps, so I am discussing some of them. If they have been corrected, great. Hopefully, some of what I have written will stimulate some thought. It might provide some insight as to how your government works.

Move to Sacramento

I spent my first 19 years on Long Island. I graduated from a small college in West Virginia with a degree in Civil Engineering in 1962. Back then they had a draft, so I had gone through ROTC and after graduating became a C-130 navigator in the Air Force. I was stationed in Sacramento for a year and liked it, so when I got out of the Air Force at the end of 1967, I looked for a job there. The cost of living was good and there were lots of educational opportunities. San Francisco and Lake Tahoe were nearby. The weather is nice. I had a friend there, in the Air Force who got me a date with his neighbor. It worked out pretty well. We've been together for 57 years.

The Sacramento District of the Corps of Engineers hired me. I was lucky.

Training Program

The Corps had a training program where they sent you through various sections in the District. I wrote specs, checked submittals, surveyed flood damages, inspected construction, etc. I was an inspector at the Mather hospital when they were building it. Kind of interesting and fun. It looked to me like, if a contractor could do something wrong before you noticed, it stayed that way.

On Corps jobs, at that time, specs took precedence over the drawings. I was a junior inspector, and the other inspectors enjoyed teasing me. I enjoyed upsetting them a little. The hospital was framed with 25-gauge metal studs. The specs said that the heavy door frames were to have 16-gauge studs. The contractor had already framed them with the flimsy 25-gauge studs, so it was fun pointing this out to the inspector who was responsible for the framing. The flimsy studs stayed in. I wonder how those doors are doing 50 years later? Hopefully still closing.

The government required that all holes on the roof must be covered presumably so workers wouldn't fall through. Some poor guy needed a piece of plywood and picked up the plywood covering a hole and walked through the hole. He was off work for about a month.

Project Planning

When I got off the training program, I was assigned to a project planning section. In that section, we designed projects and determined if they were economically feasible: the benefits must exceed the cost. I think then, we were using an interest rate of 8%. I wonder what they are using now?

It's interesting that normally, individuals and businesses try to maximize the return on an investment. The government, at that time, only cared if you could afford it based on the given interest rate.

The Corps had recently completed two reservoirs: Buchanan and Hidden Lakes. Also, legislation had recently required Environmental Impact Statements for these projects. My coworker and I were assigned to write the EISs. So, possibly, we wrote the first EISs prepared by the Corps. I doubt we spent more than two weeks writing the statements. What are the Environmental Planners charging for an EIS now?

About that time, the Arabs reduced our oil deliveries, and I started riding my bike to work. I used to ride in with the chief environmental planner and his lieutenant. They both quit riding after awhile. I kept it up for 23 years: about 100,000 miles just riding to work. Probably saved enough fuel to get Nancy Pelosi to San Francisco one way one time. I've ridden about a total of 250,000 miles. I raced for about 40 years.

Reservoir Operation

In about 1975, I moved to the section that operated reservoirs. They changed the name of the section a few times. This section was responsible for the flood control operation of 40 plus reservoirs in the California Central Valley, Utah, and Colorado. We prepared and revised operation manuals, managed reservoir releases, planned new projects, did flow frequency analysis and answered letters. Although we were theoretically responsible for flood control, many of the reservoirs were multi-purpose, and we had to consider power, irrigation, etc.

We simulated reservoir operation using a program called HEC5 using boxes of Hollerith cards. We took the boxes upstairs to the computer room where they read the cards and sent the instructions to Berkley where people ran around with tapes to run our programs. When we made a change, we marked a pink card and inserted it in the proper position in our box of cards. A key puncher would copy our changes to a new card and generally we would get our run back the next morning. Later on, they made a key punch available so we could make our own changes.

Then they gave our section a minicomputer. Wow! That was heaven. Instantaneous gratification. The purpose of the mini was to computerize our data, reports, and operation studies. I think I came into work one day and our IT guy told me he had upgraded our ram to one megabyte. The mini was on a raised floor in an air-conditioned room. I can't remember how much data it could store, but it wasn't much. We had terminals at our desks and printers. Holy moly.

I bought a Commodore 64 computer for home use. I could talk to our mini at work with it. My present computer cost about $400 and has eight gigabytes of ram and 500 gigabytes of solid-state storage. I back it up on two 125 gigabyte thumb drives which cost me $10 apiece. There is no way I would have anticipated $10 for 125 gigabytes.

All our historic reservoir data was put on the computer, and our reports were computerized. My tech in college was a slide rule. I took a Fortran 2 class at a local junior college in Sacramento. I wrote the program that computed the allowable storage for the daily reports using Fortran.

One of my coworkers wrote a really great program he called No Hands. It could manipulate hydrographs, rout flows and operate reservoirs. I loved it. Later on, he wrote another program called No Brains. I wrote some subroutines for No Hands. One of which could operate a gated spillway. HEC5, the Corps official reservoir operation program, couldn't operate a gated spillway.

The reservoir operation section was split in half. One half responsible for the northern California, Utah, and Colorado reservoirs and the other half responsible for the southern half of the central valley. I eventually ended up I charge of the southern half of the Central Valley.

There was a division office in San Francisco that supposedly managed the Los Angeles, San Francisco, and Sacramento Districts. One GS 14, I'll call him Joe, was supposedly monitoring our reservoir operation. Lake Kaweah was resurveyed and found to have less storage than thought at the time, so there was a chance that we would have to empty the reservoir to provide the required rain flood space. If we did that, the boats in the marina would have to be pulled out and stored on land somewhere. I wrote a letter to Joe, in Division, asking him if we should pull the boats out or break the law. He wouldn't answer it, so the next year I wrote a letter telling him what I would do if he didn't answer the letter. He never answered. We never pulled the boats out and eventually raised the spillway to provide more storage which solved the problem. Our Section did the studies for raising the spillway and wrote a report for that project for about $40,000. I went to a meeting where Environmental Planners had spent $200,000 and had nothing but a list of endangered species in the area. They could get the list by sending $10,000 to Fish and Wildlife.

At some point, the Corps got audited and I guess, if you were a GS14, you should be supervising somebody. It was alleged by somebody, not me, that Joe in Division hired two GS13s to supervise and justify his grade. They in turn supervised us. They would call us up and tell us to do something stupid and we would tell them to put it in writing. They wouldn't put it in writing, so we didn't do it.

I revised or supervised the updating of operation manuals for a number of projects. One day, our section chief told me my next update would be Don Pedro on the Tuolumne River. I was sitting in my cubicle, and he was standing in the aisle looking down at me and pointing his finger. He said, "do not change the operation," because if I did, the environmental planners would have to do an expensive Environmental Impact Statement. So, I updated the data and used the Corps new format. When I submitted the updated manual to Division they said we had to give the Environmental Planners $20,000 to determine if there would be any environmental impact. We said, "but we didn't change the operation." They said, "you changed the format." I have no idea whatever happened to that manual. We didn't give the Environmental Planners any money while I was there. Don Pedro has a gated spillway, but the manual had no guidance for operating the gates. More on that later. We had previously paid one of the Corps Attorneys $800 to determine if our Success Lake, now Schafer Lake, update would impact the environment. So, from $800 to $20,000. Those Environmental Planners were expensive.

One day, two people from the San Francisco Division came to the Sacramento District, I guess to explain to us that, if we needed environmental work, our expensive Environmental Planners must do it. There were just four of us at the meeting: an SES (senior executive service) and GS16 from Division and a GS14, call him Mickey, from the district and me. This is one of my favorite memories. Whenever the SES would start to talk, our Mickey would say out loud to me, "get ready, bend over." He was giving this guy the same respect that Dilbert and his coworkers would give their pointy haired boss. I don't think I was reading Dilbert at that time though.

We had to answer a lot of letters. One day I was given a letter accusing us of operating Pine Flat, on the Kings River, improperly. The letter was from a lawyer on behalf of a water district on the San Joaquin River. Part of the Pine Flat justification presented in the 1950s showed how Pine Flat would have been operated during the 1906 flood. The operation was shown graphically. Crosshatches of various colors were used to show where the river flow would be sent. The Sacramento District had a copy of the drawing and apparently, there was a copy in Washington DC. The lawyer, I think, had a black and white zerox of the Washington copy. There were crosshatches that were different colors but looked the same in black and white. So, I explained that the lawyer was misinterpreting where the water was going. I must have done a good job because it only took a few seconds for my boss to throw my answer in the garbage saying, "we're not helping them." We replied the lawyer was wrong not explaining why. So, the water district paid this law firm for months, maybe years, and lost their suit. I think about this often, thinking maybe I should have leaked. But the water district manager didn't like me, and he probably would have told the Corps who leaked. I know he didn't like me because he told me so. So, I don't have to feel bad. I valued

my job and if I had done something like that, there is no telling what the Corps would have done to me.

Some guy in Washington DC had updated our EM 1110-2-3600. I think probably Leo Beard wrote the first one. My boss told me the guy who did the revising was looking for comments and was coming to Sacramento. I felt he had screwed up the section on gated spillways, so I prepared some comments. When I gave them to my boss, he said the guy just wanted to get the manual out and wasn't interested. Guess he had a girlfriend or wanted to ski or something.

I had done some spillway gate operation simulations for Millerton Lake, with No Hands, and sent them to the Millerton Lake (Friant Dam) operator in Fresno, asking him if his operators could operate the gates as in the simulation. He showed the simulations to his operators, and they said that they would have to operate the gates while they were underwater. Apparently, at some time, the Friant Dam spillway gates could be operated remotely, but they lost that capability, if they ever had it, a long time ago. The spillway gates, presently, had to be controlled by turning valves in a chamber inside the dam. The operators got to the chamber by driving across the dam in a vehicle and climbing down into the dam. The dam had a parapet, so water could be stored above the road, but the parapet had drain holes so the road on top of the dam would be unusable when the water was above the dam road. If water could drain onto the road, it could drain into the chamber where the gate valves were operated. We developed new rules so that the gates could be fully opened and the dam evacuated before it was overtopped. Our environmental planners made us give them $30,000 so they could evaluate the impact of our new operating rules. We're talking about something that might happen about once in a hundred years. I managed to get a job at the BOR before they finished their evaluation. One day while I was at work at the BOR, somebody gave me the Corps report on the Friant operation change. Somehow the corps had put the old rules that had the operators underwater in the report. So Environmental Planners had spent $30,000 investigating no change and the operators would still be in danger. I told someone at the Corps they had the wrong rules in the report. I have no idea what they did with the spillway gate operation rules.

In February 1986 there was a huge storm in the Central Valley. It washed out a coffer dam on the American River and threatened disaster in Folsom Lake. I lived close to the American River. I came home from work and helped my wife put important things on our second floor and sent her along with our kids and dog and our neighbor with her kids and dog to a motel on high ground. Then I went back to work expecting to find coworkers there to help with flood operations. Nobody had told me to come in, but I assumed that at least some coworkers would be there. It was difficult to get back to work because the intense

rain had made many streets unusable. I got to the office and found our branch chief, Jack, my boss's boss, and his young daughter there. That was it. Folsom Lake was not my responsibility, but I built a computer simulation using No Hands. I believe the design channel capacity of the American River was 115,000 cfs and Folsom was releasing 130,000 cfs. I'm not sure of the 130,000, possibly it was a little less, but certainly more than the design channel capacity. After I had built the simulation, I believe it had stopped raining and a recession was about start I found Jack walking around in circles saying ,"we've got to go up," and he was about to call the state. I showed him my simulation that showed we didn't have to go up. He didn't, and we ended up surcharging Folsom by 20,000 acre-feet. At the time, we thought we could surcharge to 60,000 acre-feet. I planned the draw down of Folsom releases assuming and hourly recession rate of .95. In 1997, my coworker across the aisle at the BOR was given the task of planning the Folsom release draw down. He said something about an inflow forecast and I told him to try .95 and he liked that and it worked. During that 1986 flood, I stayed up all night at the office and then went to the motel where my family was. When I went to our room on the second floor, I looked over the rail and saw my coworker who sat next to me at the Corps leaving to go to work. Like me, he thought it was a good idea to spend the night on high ground.

About 5 years later, I met a guy who lived next to the Mayhew levee which was on the American River. He told me his neighbor had stayed up all night, and the river was within 3 inches of overtopping the levee, so very likely, surcharging 20,000 in Folsom Reservoir saved Sacramento. Right after the flood, I had ridden my mountain bike on both levees from the River Bend Park to the Sacramento River and saw sticks stuck in the levee less than a foot from the top.

 My section chief, at the corps, a GS13, retired. Instead of advertising his position they appointed a new chief: A GS14, call him Fred, who needed a job and had bumping rights: he could take some other GS 14's job if he lost his. So they gave him my boss's job but he kept his GS14 salary. He had no experience operating reservoirs, so I wrote a Grievance. I didn't want to teach him his job and I was pretty sure he didn't want me to teach him. So, I was invited to a meeting with a bunch of people who outranked me, one of whom was the District Engineering Division Chief, I'll call him Lenny, and they talked me out of calling my Grievance a Grievance. I never saw our Fred again, but I'm pretty sure he kept his title and salary. We had to do his job now. Lenny wrote a memo saying that Fred was fully qualified to be our chief, but we never saw him again.

Folsom Reservoir was not my project, but when I was the acting section chief in about 1993, doing Fred's job, a letter concerning its operation came across my desk. Before letters went out at the Sacramento District, or probably any District, they were routed to

people who might have an interest in the letter topic. The letter concerned assumptions about upstream reservoirs during a flood, I wasn't concerned about the letter topic but I felt that the space requirement in Folsom Reservoir during the rain flood season was BS. After the 1986 flood, my coworker developed a flow frequency curve that put Sacramento in the 100-year floodplain. The space required to control rain floods in Folsom Lake was enlarged to accommodate the 100-year flood, but the reservoir was not required to draw down to the required level until January. The Central Valley has had rain-floods as early as September. There is certainly a good chance for floods in December, so I wouldn't sign off on the letter. I thought it would be fun to listen to someone telling me why we didn't need space for rain floods in December. That never happened. They changed the space requirements that had already been approved. I think the late space requirement had something to do with power generation, but how do you convince the chain of command all the way to Washington that it won't rain in December. We had a huge flood that started at the end of December in1997.

I decided to look for another job in another agency since the Environmental Planners were in control and Lenny told me that Fred could handle the job. A guy I was supervising told me about a job at the Bureau of Reclamation. I'm not sure, but maybe that was a good way for him to get rid of me. I got the job. Smart guy.

When I lived on Long Island, I liked to watch stock car races in Freeport. The guy at the BOR who hired me had raced stock cars at Freeport. I might have watched him. He also told me he worked with Leo Beard at the California DWR and had shown him the Log Pearson Type 3 frequency distribution. I am pretty sure that is the official frequency distribution used to map the 100-year flood plains throughout the US. Small world. So, it's possible that a stock car driver from Long Island is responsible for how FEMA determines who is in the 100-year flood plain. I think that this stock car driver probably had at least a master's degree in some science though.

In 1995, I was sleeping peacefully when my phone rang at about 0230. It was my friend Tony in Fresno who was in charge of Millerton Lake (Friant Dam) operation. He had something like 53,000 cfs inflow and not much reservoir space left. He tried to call the Corps, but none of the phone numbers in the manual worked. So, I called Lenny, the chief of the engineering division at the Corps, and told him that Fred had forgotten to put his phone number in the operation manual. Remember, Lenny told me that Fred was fully qualified to be the section chief. I was a hydrologist at the BOR now and not responsible for any reservoirs. When Tony looked at the next hourly inflow, it was something like 52,000 cfs, so the recession may have started. I made a simple Lotus 123 model assuming an hourly recession of .9. It looked like we could get by releasing the channel capacity flow of 8,000 cfs. I didn't have internet then, so I put my model on a floppy disc and drove over to Cottage

Way in Sacramento and threw pebbles at someone's window at about 3 in the morning to get in the building. I gave the floppy to someone at the BOR involved with operation and communicating with Tony and went home to bed. About 20 hours later, inflow equaled outflow and Millerton Lake was about .5 feet from full. Beautiful!
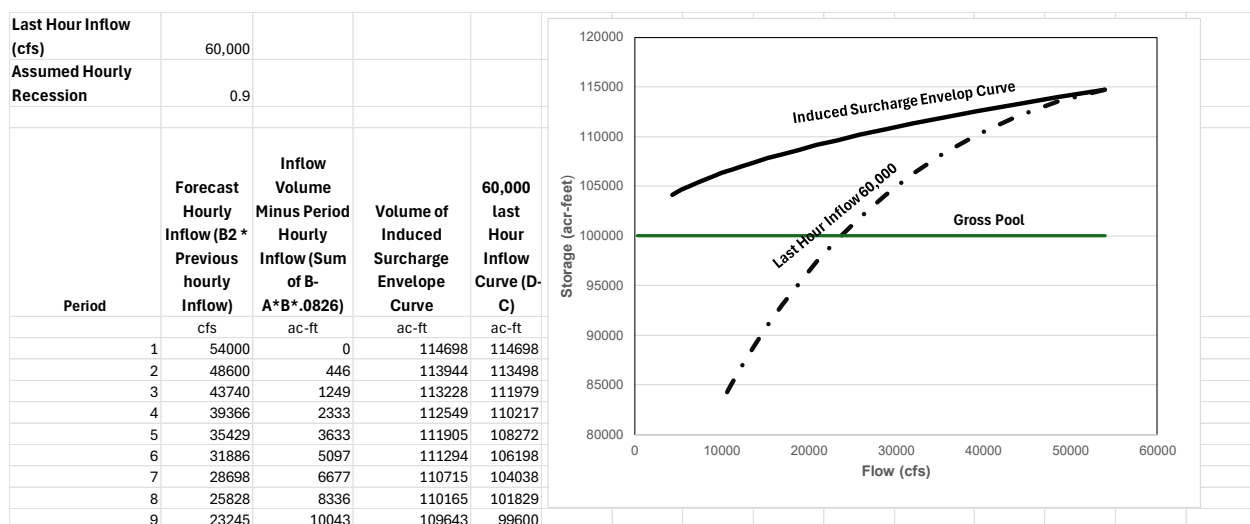
Recessions

My opinion is, that the worst thing you can do during a flood is make a release exceeding channel capacity and flood somebody and not fill the reservoir. I think Leo Beard also felt the same way. So, when deciding what to release during a flood, you need a forecast of what the minimum inflow is likely to be. I think Leo thought that should be based on the assumption that the last inflow was the peak and the recession would now start. Sounds good to me. If you look at past basin flows you can come up with a reasonable recession coefficient for a given basin. An hourly rate of .9 worked on the San Joaquin and .95 on the American River. I think a .9 would work on the Tuolumne. Spreadsheets make it really easy to forecast inflow based on assumed recessions. Before spreadsheets we used formulas to estimate volumes based on recession rates. The first EM 1110-2-3600 stated that the volume from 0 to infinity was $Q*(-Cr/\log_e Cr)$. The trouble with that formula is flows are computed as averages during a period: maybe an hour or a day. The flow rate equaling the computed average flow occurs somewhere near the middle of the period, but the integration starts at the beginning of a series of tiny increments, so the formula is a little off. I think it was used to compute spillway gate operating rules in some reservoir operation manuals. This formula appears to work: Sum from $Q1$ through $Qt = Q1/(1-Cr)-Q1*Cr^{(t)}/(1-Cr)$. You don't really need a formula now anyway with spreadsheets and computers.

Gated Spillways

Spillways that are gated have the ability to make large releases before the reservoir is full. Gated spillways, in some cases are less expensive than the freeboard and spillway width required to control the spillway design flood. If the minimum inflow forecast shows that you will have to make a release exceeding channel capacity, then the earlier you get started, the lower your peak release will be. A low forecast keeps you from getting started to early. The EM 1110-2-3600 that was in effect when I started working in the reservoir control section talks about an induced surcharge envelopes curve. That's a curve that requires a release based on reservoir elevation above gross pool. As best as I can tell, it either shows releases required to control the spillway design flood to save the dam or releases required to maintain the proper freeboard for certain types of spillway gates. The EM 1110-2-3600 said you should try to store floods up to that curve if you are going to exceed channel capacity.

You do that by computing a release that will cause your lake elevation to rise to the level that requires your release on the induced surcharge envelope curve. Some of the Corps projects have graphs that show you what to release given a specific inflow and lake elevation. It's a simple matter to compute these graphs. Here is a simple example. Of course, more last hour inflow lines should be computed. In this example, if your storage was at Gross Pool, and your inflow during the last hour was 60,000 cfs, you should be able to release about 25,000 cfs and inflow would be equal to outflow when you stored to 110,000 acre-feet. If the flow kept going up, then, of course, you would have to increase your release the next hour. If it didn't, then you had an inflow of 60,000 cfs when you were full but only released 25,000 cfs. Good job.

Last Hour Inflow (cfs)	60,000			
Assumed Hourly Recession	0.9			
Period	Forecast Hourly Inflow (B2 * Previous hourly Inflow)	Inflow Volume Minus Period Hourly Inflow (Sum of B-A*B*.0826)	Volume of Induced Surcharge Envelope Curve	60,000 last Hour Inflow Curve (D-C)
	cfs	ac-ft	ac-ft	ac-ft
1	54000	0	114698	114698
2	48600	446	113944	113498
3	43740	1249	113228	111979
4	39366	2333	112549	110217
5	35429	3633	111905	108272
6	31886	5097	111294	106198
7	28698	6677	110715	104038
8	25828	8336	110165	101829
9	23245	10043	109643	99600

Somebody should be able to go through this in a day or two. How much money would the environmental Planners need to determine the impact on the environment. This needs to be done for Don Pedro. Keep in mind it is not something that is used very often.

When I left the Corps, I think the rules for operating the gates on the Lake Oroville spillway were based on the change in lake elevation during the last hour. The change in lake elevation is caused by the difference in inflow and outflow. You need to know the outflow so you can compute inflow to estimate future inflows from a change in elevation. That needs to be looked at. You can't tell your inflow from and elevation change unless you are releasing nothing.

In December of 1997 there was a record flood in the Central Valley. I helped Tony with the Friant Dam operation. I don't know if the Corps had implemented the new rules for operating the spillway gates. I doubt it. I don't think they were any help with Friant at all. Although it wasn't my responsibility, I helped Tony with Friant operation. He had a broken leg so he had to hobble around on crutches. It turns out that the spillway gates interfered
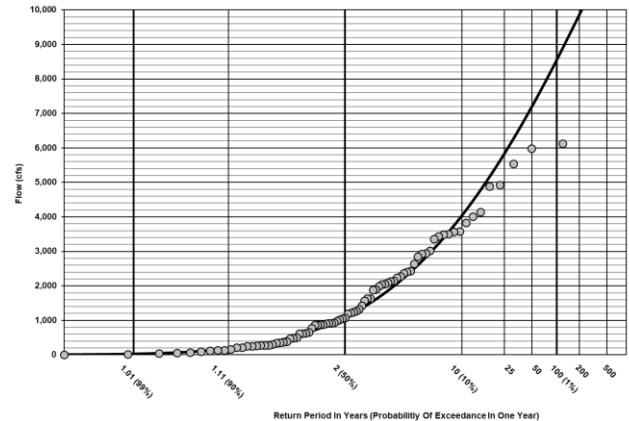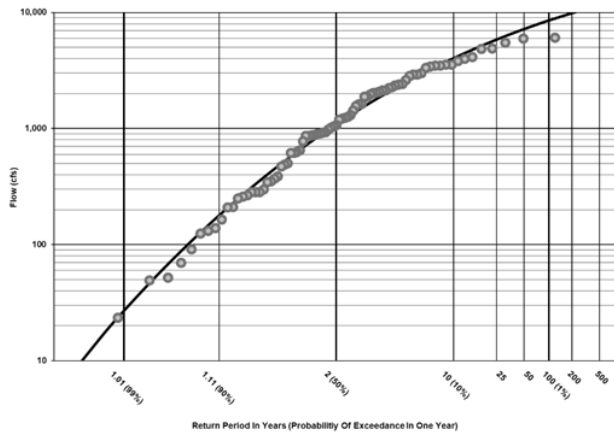
with the gage that shows lake elevation, so the operators were determining lake elevation and, in turn, determining inflow with a tape measure by leaning over the parapet. That's how high the lake was. I don't know if Tony with his broken leg was doing any measuring. Assuming a .9 hourly recession, releases exceeding channel capacity were initiated before the lake was full and although the inflow was 95,000 cfs, the max outflow was no more than 68,000 cfs; fantastic!

When I worked at the Corps, I wrote a subroutine in No Hands that could simulate gated spillway operation. HEC5, the Corps official reservoir operation program, did not have that capability. My coworker, who wrote No Hands, eventually left the Corps. When I left, No Hands was no longer supported, so they lost the ability to simulate reservoirs with spillway gates. I don't think people were using pencils anymore. Hopefully, by now, 30 years later the Corps has the ability to simulate gated spillways.
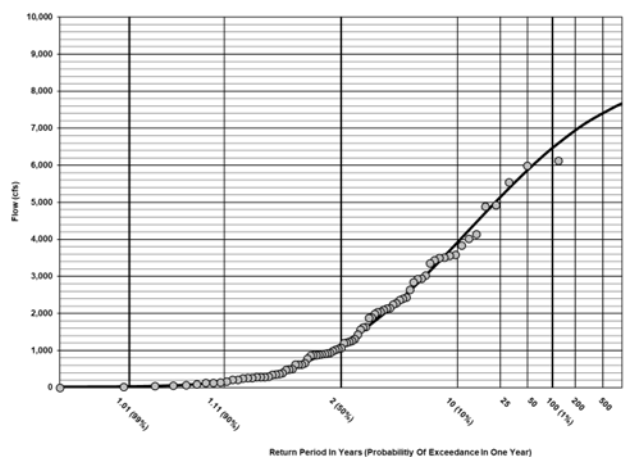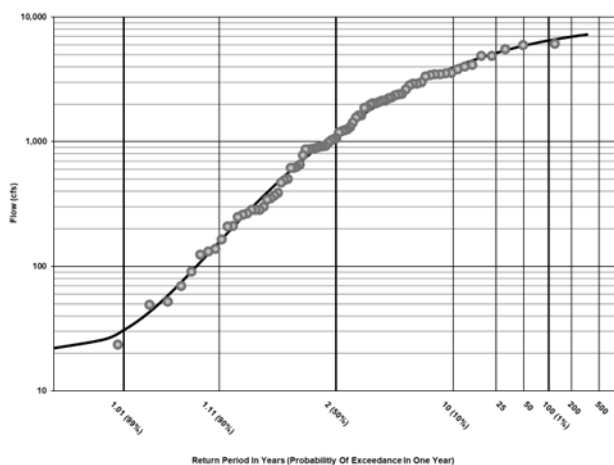
Flow Frequency

When I worked at the Corps, I studied some report that supposedly showed that applying the Log Pearson Type Three Frequency Distribution was the best way to estimate flow probability based on historic data. It looked to me like the study wasn't very conclusive, but our government wouldn't allocate any more money for the study. I haven't seen this written, but I think the logarithms of flows are used because negative logarithms are fractions, not less than zero. If you are using a normal distribution, an event with a one percent chance of exceedance is the mean plus 2.32 times the standard deviation. An event with a 99% chance of exceedance is the mean minus 2.32 times the standard deviation. I some cases, that could turn out to be a negative number and you would have explain why you had a 99% chance of exceeding a flow of -2000 cfs. I'm pretty sure there is a 100% chance of that.

We always plotted our frequency curves on log probability paper. The Y axis was logarithmic and the X axis in standard deviations. My bet would be that the Corps got started with log probability scales because a ships curve worked nicely or possibly because we were using the logs of the flows. But logarithmic scales are misleading because the high numbers are given the same area as low numbers: the distance between 1 and 10 on the Y axis is the same as between 10.000 and 100,000. This makes a frequency curve look like it fits the high flows well when it really doesn't. This works for the "if it looks good, it is good," requirement, but it's misleading. Both of the curves below will give you the same flow for a given frequency.

There are many streams that have historically not gotten close to a 0 flow rate. You can guarantee the maximum annual flow for a year will be above some value. If you acknowledge that there is a base flow guaranteed to occur and only compute the statistics from the flows above that value, your frequency curve will probably fit your data a lot better. Why would you include something that is guaranteed in the data you use to determine the probability of flows. Of course, you must add your base flow to your computed frequency curve. The following was computed from the same flow data as above only an assumed base flow was subtracted before the statistics were computed. The base flow was computed so as to minimize the difference between the historic values and curve values for the probability assigned to the historic flows.

When using logarithms, low flows can have a great impact on the computed statistical parameters. 10 is 1 /1000th of 10,000 but the log of 10 is 1/4th of the log of 10,000. Bulletin 17B has ways to handle years with no measured flow. I don't think there has been a year of no precipitation in the central valley of California, so there must have been some flow every year; just not measured in some cases. If a rain drop lands on a rock, there will probably be

flow; 1/1,000the of a cfs, maybe, a log of -3. What will that do to your skew coefficient. I don't think that the LP 3 distribution fits all flow data. Bulletin 17B has ways to adjust.

Space is required to control rain floods with our reservoirs. The Corps develops design floods and determines how much space is required in a reservoir to control the flood. They require the reservoir to have that much space available and say they are protecting you from floods of that magnitude. However, they don't require that space throughout the seasons when a storm may occur.

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Sum
Pobability that Max Storm will Occurin this Month												
0.02	0.1	0.25	0.25	0.24	0.07	0.04	0.02				0.01	1
Probability of Storm Controlled by Space Provided												
0.5	0.02	0.01	0.01	0.01	0.02	0.03	0.5				0.9	
Probability of Beiing Flooded this Month												
0.01	0.002	0.0025	0.0025	0.0024	0.0014	0.0012	0.01	0	0	0	0.009	0.04

If enough space to control a .01 flood were provided in months when there was any chance for a rain flood, the annual probability of spilling would be .01, but instead, in the above case, it's .04. I think that some regulation authors think that if there is less chance for a flood, then the space required may be reduced.

It should be noted that many reservoirs provide more than the claimed protection because, in many cases, they provide more space to control floods than required because they are multipurpose. When I worked for the Corps, they assumed that the only factor that affected outflow from a reservoir was the inflow. They assumed that, in every case, the initial conditions (empty space, storm distribution, upstream conditions) would be static: the probability of the outflow equaled the probability of inflow; very unlikely, ridiculous. The estimated probability of outflow from a reservoir should account for all unpredictable outflow influences.

Self Employment

When I left the BOR, I worked for myself. I got a programmers certificate from Freeport U by the Zoo, aka Sacramento City College. I thought I would like to be a programmer, but I couldn't find anyone who wanted to hire a 60-year-old programmer. I did find some engineering work.

I was hired to complete a Monte Carlo analysis of outflows from Friant Dam. I used random numbers between 0 and 1 to determine the date the flood started, the initial reservoir storage, initial upstream storage, flood distribution, and flood volume. I generated tens of thousands of years of annual flood events. Guess what? The results showed that you don't

need a 1% inflow to get a 1% outflow, and you can get a less than 1% outflow from a greater than 1% inflow.

Conclusion

There were some smart honest people that I worked with. I don't think any of them were in the San Francisco Division office or were environmental planners.

It looks to me like government managers discovered that environmental protection is a good way to keep the money coming in. There was a law and probably still is that said you could not change the way reservoirs were operated without some type of environmental documentation. I think environmental planners were very expensive and had no accountability. In my case, they interfered with work that needed to be done.

Environmental agencies spent a fortune trying to increase the Salmon population in the San Joaquin River. There was a time when fish counts (Salmon) were published but then stopped. I think people were computing the cost per fish, and they were expensive. If people want the fish and don't mind the cost, fine, but the cost should be published, just like the cost of solar energy, windmills, dams etc.

Hope you enjoyed this.