LOCAL PERSPECTIVE
OF RISK-BASED ANALYSIS
ON FLOODPLAIN MANAGEMENT ACTIVITIES

by

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THE CLIENT

There are two (or possibly three) client types that an engineer in private practice may encounter. The first type is the Private Client. This is normally a client who engages the engineer to perform a service which the client cannot perform because that client lacks the expertise, training or license to do the floodplain management analyses required for a particular project. The typical Private Client is a developer. A Public Client may be a city, county, special district, a state or a branch of the federal government. This client may hire the engineer for the same reason that a Private Client does, or the Public Client may hire the engineer to perform a service which the client does not have the workforce availability or the time to perform. This second type of client may also hire the engineer to be a "sacrificial lamb" or possibly to "be a shoulder to cry on". Analytical tools, procedures and results are of lesser importance when these two reasons are behind the hiring of the private engineer.

The possible third client type is that of Attorney. In this case the engineer may be hired by a private firm or a public agency to represent the interests of a party to a litigation. This type of client normally hires the engineer for expertise, but often expects to hire an advocate for the party's interests. While this may be sometimes expected it should not happen with professional engineers because their goal should be to hold preeminent the public's health, safety and welfare. When the engineer "tells it like it is" to the best of his ability that engineer is performing a true service to the client, the party represented and to the court and thus the public.

Whichever client type the engineer has when doing floodplain management analyses functions that engineer is expected to perform those analyses in accord with the current standards of practice at the place of performance.

RISK-BASED ANALYSES

The Standard of Care which must be met by a practicing engineer is to do the work with the care normally exercised by a typical engineer performing like services at the same time and in the same location. It is this standard by which the engineer must do his work or face the specter of liability - both financial and professional. It is this liability which makes engineers so conservative in their approach to problem solving. If practicing engineers in the private sector had the immunities from liability that the Corps of Engineers enjoy there would undoubtedly be more explorations into scientific and mathematical crevices by the engineering community. It is interesting to contemplate and debate whether limitation of liability would in fact create the absence of the need for engineering registration or conversely would create the need for tougher, more meaning, more consistent licensure laws to better protect the public. Other viewpoints indicate that elimination of licensure laws but imposition of strict liability for engineers would better protect the public than the existing system of Standard of Care.

In any event the Standard of Care undoubtedly slows down the incorporation of new analytical procedures into day-to-day practice.

Coupled with the Standard of Care issue is the private practice engineer's lack of protection from the "law of large numbers". Unlike some large federal agencies which may do hundreds of projects in a year, a typical engineer in private practice may do only a handful of floodplain management protection projects in a career. While statistical techniques work on the average, if the "outside of the average" hits during your watch, you are in for some rough sledding through second guessing, self doubt, loss of professional reputation and likely loss of future revenues. There are a couple of examples which come to mind when thinking about the conservative nature of engineers.

The first example is from the construction history of Hoover Dam. According to an account in *Hoover Dam, An American Adventure*, by Joseph E. Stevens, after the diversion tunnels had been started on both sides of the canyon there was a flood on September 26, 1931. The levees constructed in front of the portals to the tunnels held and there was no damage. However, in February of 1932 when the tunnels were well along inside the rock abutments, a warm rain fell on an early, heavy snow pack in the watershed along the Virgin River. The flood of February 9, 1932 did not enter into the tunnels due to human intervention involving sand bagging to bolster the levees. However, the flood of February 12, 1932 was much greater. It tore into the levees, breached them, flooded the partially completed tunnels and left a set of diversion tunnels aquiver with gelatinous muck.

After the September flood no high water was expected until next summer's flash flood season when the tunnels would have been completed and the coffer dam would have began construction.

The second example is that of the coffer dam sizing that we have all done as part of our engineering economics course. Remember the problem: size the coffer dam to minimize the expected cost. Costs are due to damage and to construction. The higher the dam the more the construction cost but the lower the expected damage. We have all done this problem and felt good about the result.

In the first example there was a failure and a cost even though the engineer had figured that the summer thunderstorm floods could be protected against. For the engineering economics problem the answer we all came up with would work well on the average. If the engineer does a lot of coffer dams he may get a failure once in every fifty or so but hopefully by the time this happens that engineer's reputation for prudently designing coffer dams would probably be in place. If, however, that engineer's first coffer dam failed just like the levees in front of the portals to the diversion tunnels at Hoover Dam, that engineer might never get another chance to design a coffer dam. Therefore, engineers act conservatively, maybe more conservatively than statistics would dictate because of the awesome responsibility to protect the health, welfare and safety of the public.

THE REGULATORY CLIMATE

When doing floodplain management analyses for a client, the engineer is often constrained by the regulatory climate of time and place. Local ordinances set up standards of performance which the local citizens wish to have implemented to provide for their health, welfare and safety. Generally the engineer must adhere to these standards except in the case where the standards are believed to be inadequate and the engineer must design to a higher standard.

The local staff may have a different interpretation of local ordinances than does the practicing engineer. In this case negotiations may have to be undertaken to satisfy staff of the propriety of the engineer's analysis. Depending upon the staff make-up and expertise, this task may range from very simple to tedious, nerve-racking and technically complex.

Besides local ordinances there are federal and state statutes with which the engineer must comply. Typically encountered are the FEMA regulations which the engineer attempts to understand and comply with before submitting applications to FEMA for letters of map changes.

Last but certainly not least is the decision-making body. Often the engineer must present the results of floodplain management analyses to such a body for an official acceptance or rejection. These bodies are usually made up of non-technical people (often innumerate) who are highly educated, articulate, literate and often aggressive. The questions that they pose will usually challenge an engineer to think about the project in a totally different manner. Often these sessions will take on the air of a college lecture if the engineer carefully explains the results in terms that laypeople must strain to comprehend. The bottom line here is the acceptance of a line on a map, the size of a culvert, the height of a levee, the depth of a channel, the height of a dam or the length of linear park. No matter how much probability and statistics goes into the analyses of the project, the final outcome becomes a finite value which decision-makers can accept or reject. Now, the engineer can couch the results in as many disclaimers as necessary, but the final outcome will be an acceptance or a rejection of a line on a map, the size of a culvert, ...

EXAMPLES

Client type, Standard of Care and the regulatory climate all combine to constrain the practicing engineer from implementing risk-based procedures. Some recent examples of some of the limitations are described below.

<u>Level of Protection</u>. While in theory the cost of a given level of protection should be balanced against the expected average annual damages, in practice a number of things constrain the engineer to provide a 100-year flood level of protection for urban land uses. The only urban uses which may

have different, higher levels of protection are hospitals, sewage treatment plants and other vital public facilities. Nuclear power plants are usually protected to the probable maximum flood level. These levels are dictated by regulations: federal, state and local. As a rule, floodplain management engineering does not even look at alternative levels. Adherence to the regulations is all that is expected and generally all that is done for a particular project. Risk-based analyses are virtually absent in determination of level of protection for urban land use projects.

Freeboard. This one project parameter has seen some very interesting applications in floodplain management. Certainly everyone familiar with floodplain management knows of FEMA's dictates when considering freeboard for levees; but other than levees there is no FEMA regulation regarding freeboard for any other type of floodplain damage mitigation project. This can be quite disconcerting to the practicing engineer when there is no freeboard requirement in situations where there is a floodway designation. The floodway designation, as you no doubt know, usually allows for a one-foot rise in water surface elevation due to fill along the fringe areas. However, the regulations allow first floors to be built at the water surface elevation prior to the floodway designation. This means that some structures may be constructed one foot too low when complete build-out occurs.

1) **Some Like It Hot!** One Special District which is responsible for flood control and water supply routinely requests that first floors be constructed at least three feet above the FEMA regulatory water surface elevation: one foot for freeboard, one foot for future land use placement (the floodway effect), and one foot for increases in peak discharge. Unfortunately this Special District has no land use authority and, therefore, has no say in first floor elevations. Also unfortunately this Special District usually requests that development utilize detention basins so that water surface elevations will not be adversely impacted, thus negating the argument for one-foot increase in first floor elevation due to the peak discharge increase. This District appears to be slow-growth in philosophy and appears to attempt to act as a halt to residential, commercial and industrial development.

2) **Others Do Not!** The largest City within that Special District has an opposing view of freeboard. None is required. FEMA does not require it, so that City's ordinance does not require it; staff and the Council feel that the City burdens development enough already with current regulations and does not impose anything beyond the minimum standard for floodplain management. The City is pro-growth, particularly the industrial type of development.

3) **The View From the Bench**. Attorney's have a ball with the freeboard issue. The usually framed question goes something like: "will the levee fail when the water enters the freeboard range or is the project expected to pass all the flow up to the top of the levee?" Certainly many attorneys have a real knack for framing questions in black and white when in reality they are actually a shade of gray. Often if something is not "right" then it is obviously the converse - "wrong".

In the expert witness testimony about freeboard there appears to be a great gulf of opinion about what freeboard is and how projects are expected to react when operating in the freeboard range. The new terminology of risk-based analyses which uses "probable failure elevation" or some such terminology has inadvertently added a degree of specificity to the operations in the freeboard issue. Now it is commonly assumed that when the water level rises to this "probable failure point" the project will fail and if it is a levee project the consequences may be catastrophic. Any deferred maintenance which can cause the water level to reach that "probable failure elevation" can now be more easily blamed for levee failures. When millions of dollars of damages are at stake and when the damages are being paid for not by the project designer or constructor but by the operator of the project, this type of terminology is not looked upon with favor by many engineers.

Hydrology. A Special District for flood control long ago had a hydrologic procedure which was based on the unit hydrograph/design storm methodology. The District decided to utilize more up-to-date statistical procedures to better evaluate the flood potential of streams under its jurisdiction. A lengthy statistical process produced results which were much, much greater than those in use from the unit hydrograph/design storm procedure. The District was convinced that these new values were superior and began using them in earnest. After twenty years of construction and planning and struggling with local cities and environmental groups the District re-evaluated its procedures because it now had twenty more years of data and there were have been some major advances in statistical techniques during that time period. The new results came out much, much lower than the old values but in line with the older unit hydrograph values. What to do!

This dilemma points out a potential problem. The problem is not that of the variability of statistical information; after all, that is statistically expected. It points out the problem with consistency of advice. The public expects safety from floods and it expects the public agency responsible to do a competent, workman-like job. When widely fluctuating values are published many people and decision-makers become nervous and suspicious of the results and the developer of the results. The real dilemma here is whether that District should keep its older, higher values and continue its flood control mission for another twenty or so years with these more conservative values and then re-evaluate or whether it should go with the latest statistical results, cut its maintenance program which attempts to keep roughness values in line with design, build smaller flood water conveyance facilities and make it more difficult for future floodplain managers to increase conveyance capacity should statistical results show much higher values when re-evaluated in twenty years.

Floodplain Delineation. Besides the typical riverine floodplain delineation analysis which must end up with a line on a map, there are other floodplain delineation problems which also end up with lines on maps but which make use of vastly different hydrologic and hydraulic procedures. One such problem is that of playa hydrology and in particular predicting the 100-year water surface elevation in the lake bed of such an enclosed drainage basin. A procedure that was utilized was that of predicting the storage in a water supply reservoir but in this case the only potential use of the accumulated water was evaporation. Through statistical techniques the monthly mean, standard deviation, skew and lag-one serial correlation coefficient were predicted for this watershed using linear regression with the seven closest stream gages. A random process was then utilized to select new sets of parameters and generate 2000 years of simulated monthly runoff/evaporation/storage traces. This Monte-Carlo procedure was then run hundreds of times to develop a statistical variation of the 100-year water surface elevation.

Even though this was considered to be a good application of statistical procedures and of a risk-based analysis for an unusual floodplain management problem, it was rejected by FEMA upon application for a letter of map amendment in favor of a 10-day design storm calibrated to the 10-day 1986 flood, coupled with an antecedent 2-year, 24-hour flood inflow to provide for carry-over storage and antecedent storms. The results were identical to those of the risk-based analysis so the client was satisfied.

CONCLUSION

Regulatory Rules!

Well almost. A combination of current floodplain management regulations at the local, state and federal levels coupled with engineering judgment is more correctly what rules the current practice. The Standard of Care is very important to the practicing engineer and is routinely discussed by these practicing engineers on individual projects. Any risk-based analysis is generally done only on an intuitive basis in a manner faintly similar to some of the built-in safety factors incorporated in development of the Standard Project floodplain.

The risk-based approach to floodplain management analyses appears to hold the hope of a better level of understanding of the risks in decision-making in the floodplain. However, in the final analysis the engineer's individual judgment will still be required to place a specific line on a map, or specify the size of a culvert, or identify the height of a levee. That engineer must usually stand before a body of decision-makers to explain and if necessary defend that decision. Ordinary citizens depend upon engineers and their judgments before investing their life savings and even their lives and, therefore, engineers should (and normally do) use good analytical tools in their work. Currently, however, there is little or no formal use of risk-based analysis tools in local floodplain management engineering.