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2001 RAY K. LINSLEY AWARD

The American Institute of Hydrology (AIH) established this award in 1986 to honor the first Vice President of AIH, Ray K Linsley - one of the truly great leaders in the hydrological sciences. The award is presented annually, on the recommendation of the AIH Awards Committee, for a major contribution to the field of surface water hydrology. The first Ray K Linsley Award was presented to Peter 0. Wolf at the AIH International Conference on Advances in Ground-Water Hydrology in Tampa, Florida on November 17, 1988.

Citation: *Stephen J. (Steve) Burges*

It is my great privilege to introduce the recipient of the 2001 Ray K. Linsley Jr. Award, Dr. John J (Jack) Cassidy, Fellow Emeritus, and Manager Emeritus Geotechnical and Hydraulic Engineering Services, Bechtel Corporation, San Francisco, California

Ray Linsley was a giant of the profession, excelling both as a professor, and as a practitioner of, hydrology and hydrologic and water resources engineering. Ray worked tirelessly to improve the state of professional practice.

It is more than fitting that AIH has chosen to honor one of the best practicing professionals from the field of hydrologic, hydraulic, and water resources engineering by linking his name with Ray Linsley.

Dr. Cassidy is currently an independent consultant in water resources engineering.

I first met Jack in 1974 at Bechtel where he had started as Assistant Chief Hydraulic Engineer. From 1975 to 1978 he was Chief Hydrologic Engineer. He then left for academe to head up the Washington State Water Research Center at Washington State University. He returned to Bechtel in 1981 as Chief Hydrologic Engineer. In 1985 he was appointed a prestigious Bechtel Fellow and also headed the Hydraulics and Hydrology group. In 1994 he was named Manager of Geotechnical and Engineering Services, a group comprising one hundred and forty specialist engineers and geologists. He retired from Bechtel in 1995.

I have had the pleasure of working with Jack on a National Research Council Committee that provided advice to the US Bureau of Reclamation and also while he was Director of the State of Washington Water Research Center. It was during my working experiences with him that I realized that he and Ray Linsley shared many fine qualities, including incisive analysis of any situation and a wonderful dry wit and self-deprecating humor.

Jack earned his B.S.C.E. in 1952 and his M.S.C.E. in 1960 from Montana State University. He earned his Ph.D. from the University of Iowa, in Hydraulics with Hunter Rouse, in 1964.

He is a Registered Professional Engineer in California, Montana, Idaho, Washington, Wyoming, and Nebraska

Jack has been involved individually and as a group leader in a wide variety of water resources projects including waste isolation, hydroelectric and water-resource dams, irrigation projects, mine developments and tailings dams, thermal power plants, flood damage mitigation works, and industrial projects throughout the world.

He has been recognized formally for his exceptional intellectual, managerial, and research and educational leadership in hydraulics and hydrology. His honors include:

Honor Member of Chi Epsilon, the Civil Engineering Honorary Society, (elected by the students of the University of Missouri, Columbia, Missouri, in 1972 where he was department chairman).

Appointed a Bechtel Fellow in 1985.

The Hunter Rouse Hydraulic Engineering Lecture, American Society of Civil Engineers (ASCE) 1988.

Deere Memorial Lecture, College of Engineering, University of Iowa, Iowa City, Iowa, 1990.

He was Elected to the National Academy of Engineering in 1994, and
Elected an Honorary Member of ASCE also in 1994.
He was awarded the ASCE Hydraulic Structures Medal in 1996.

Dr. Cassidy's contributions as an educator and his service to academe as a department chairman at the University of Missouri, Columbia, and Head of the Washington State Water Resources Research Center, Washington State University have been exemplary. He has had a profound influence on the practice of hydrologic and water resources engineering personally and through his exceptional leadership in industry at Bechtel Corporation.

Jack Cassidy has contributed significantly to the hydrology, hydraulic, and water resources literature throughout his professional career including the co-authorship of two textbooks:

Hydrology for Engineers and Planners, Iowa State University Press, Ames, Iowa, January, 1975 (with A. T. Hjelmfelt, Jr.). and

Hydraulic Engineering, Houghton Mifflin, Inc., New York, NY, 1988 (with J. A. Roberson and M. H. Chaudry).

Dr. Cassidy's published and professional work has been at the forefront of critical hydrologic and hydraulic aspects of dam safety, particularly spillway design. Few can match him for his depth and breadth in such societally important work. Few, if any, have comparable national and international stature. Inclusion of the name John Cassidy among the winners of the Ray K. Linsley Jr. Award adds considerably to its prestige and emphasizes the professional breadth and strength of The American Institute of Hydrology.

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Response: *John J. Cassidy*

THAT FLOOD IS JUST TOO BIG

A major portion of my professional career has been spent performing or supervising hydrologic designs for large industrial projects. The projects have included dams for flood control, hydroelectric production, irrigation, and various multi purpose uses; nuclear power plants; airports; mining developments; and major industrial plants. What I call hydrologic design usually includes projections of long-term streamflow and/or the development of design-flood hydrographs. Many of these projects, particularly nuclear power plants, large dams upstream from cities or towns, and tailings dams for mine mills, can be classified as "high hazard projects" since major economic loss, severe environmental damage, or loss of life would occur if the dam were to fail or, in the case of a nuclear power plant, if the project were to be flooded above acceptable limits. In modern times the high-hazard classification of such projects often requires that the design floods be the largest flood that could occur at that particular site as a result of the most severe storm that could occur over the drainage area involved, "The Probable Maximum Flood or PMF."

It has been my experience that no matter what magnitude of peak flow or runoff volume you calculate for a PMF, the project manager or the client will inform you that "That Flood is Just too Big!" I have had electrical engineers, responsible for the installation of generators at hydro plants, and ostensibly with no hydrological training of any kind, tell me with complete confidence that, "You can tell by just looking at this dam site, that it's ridiculous to think that a flood of the size you hypothesize could ever occur in this valley!" I have always thought that it must be wonderful to have such insight. Just think of the magnitude of the professional consulting fees that I could charge if I could conjure up a PMF hydrograph with no more study than standing at the dam site, meditating for a respectable but short time, and thereafter pontificating on the likely size of the flood. However, try as I might, I have never been able to develop a sense of what the magnitude of a PMF might be by "looking" at the dam site. The situation is of course, that for most projects, the magnitude of the design flood has a strong influence on the final cost of the project and one of the prime responsibilities of a project manager is to control the project cost.

In addition, Civil Engineers have an inherent disadvantage relative to their credibility as compared to an electronic engineer designing a circuit. For major Civil Engineering structures the design criteria relative to natural loadings such as earthquakes and floods, specifies design events that generally have a remote probability of occurrence. An electronic engineer generally knows whether his circuit or its components have been properly sized at or very shortly after the moment he throws the "on switch." The device either works correctly or disappears in a puff of smoke. However, a major Civil Engineering project can often pass it's entire useful life without ever experiencing a loading equal to that for which it was designed; the test never occurs.

Most people, including hydrologic engineers, have never seen a 100-year flood, let alone a probable maximum flood. People's memory of severe flooding seldom persists for more than a short time after they recover from the resulting damage. The sheer magnitude of such an event and it's destructive power is simply beyond their comprehension. Some people are more pragmatic than others and never hesitate to express their opinions, even though they really don't have the experience or qualifications to make such judgments. In fact the strongest opinions are often expressed by those least qualified to make the necessary judgment. In my experience, project developers often fall into this class. For many if not all developers, the object is to complete the project in the shortest possible time and at the least cost, and anything that jeopardizes or delays the successful completion of that project must not be allowed to stand in the way. Sometimes that attitude, carried to its ultimate, can result in the public being placed at more than acceptable risk, usually without the public's awareness or understanding.

The concept of risk is inherent in the design of all engineered projects. In many industrial fields such as the design of airplanes, automobiles or chemical processing plants, an acceptable level of risk appears to have been established in the industry. However, I don't believe that the general public is evenly remotely aware of the level of risk to which they are exposed. For example, in the design of a passenger-carrying airplane, there is a definite probability that engines or some other critical element will fail while the plane is in flight and that the plane will crash. Few if any passengers survive such crashes. Never-the-less, the vast majority of the public take flights without concern for their safety and have little or no comprehension of the morbid facts of their mortality. The airline industry obviously is aware of the probable number of people who will die in airplane accidents and that probable number is definitely not zero. However, the accepted level of probability is not published in a public document or technical journal. Imagine what the public's reaction might be if the following were to be printed on each boarding pass: "The probability of this flight safely reaching it's destination is 98.5%."

I am not aware that anyone has ever made an assessment of the risk that people living below a dam will accept. However, regulatory agencies have established guidelines which they use to set design-flood standards. In the United States that criteria has in general established that the PMF must be used as the design flood for major projects where lives would be lost if a flood larger than the design flood were to occur. Not all nations subscribe to this PMF criteria and many require that a 10,000-year flood be used as the design flood for projects where failure could put lives at risk. Still other nations require that a 10,000-year flood be used as the design flood, but that the safety of the project must not be jeopardized during passage of a PMF.

As everyone at this conference knows very well, the computation of peak flows and/or hydrographs for floods having remote recurrence probabilities, is subject to significant uncertainty. The process usually involves frequency analysis of annual peak flows which have occurred at or near the site of interest. Statistical "outliers" are a frequent problem and much has been published in the technical literature about the proper evaluation and treatment of possible outliers. Because of the difficulties involved in the development of peak flows and hydrographs for floods having a given recurrence probability, the federal agencies in the United States developed the guidelines given in Bulletin 17B published by the U. S. Geological Survey. The thinking was that, if the guidelines set forth in Bulletin 17B are followed, the peak flows or flood hydrographs developed by two different hydrologists or hydrologic engineers working independently, should be in close agreement. For the most part. the idea works well. However, decisions regarding what to do with the largest recorded or calculated annual peak flows have major effects on the calculated result. It is at this point that the ethics of the hydrologist or hydrological engineer can become challenged. If the hydrologist's initial computations receive the response that I described earlier (That Flood is Just Too Big), the pressure may trigger a need to revisit the "outliers." If sufficient pressure is applied, the hydrologist may just decide that "I thought there was something fishy about that peak flow for the 1969 flood." "After all it was determined using a slope-area calculation, and everyone knows that such methods are really uncertain at best." "If I just throw that one data point out, the flood magnitude will be smaller and more acceptable to my project manager and the client." " And after all, the calculated flood is still pretty big!"

What is the hydrologist's responsibility in the scenario I have just described? Dave Dawdy and I have recently been involved in a situation where exactly that scenario appears to have played out in the revisiting of a flood-control project. The problem involves a dam and reservoir and an associated flood channel. Development downstream of the project is significant with many private residences, commercial facilities, schools and other public facilities. Clearly the project must be judged to be one of potentially "High Hazard." The question to be answered is: "Are the dam, reservoir, and flood channel large enough to provide reliable protection for downstream developments during passage of a 100-year flood. The process of the investigation needed to answer the question appears at first glance to be relatively simple:

1. Compute a hydrograph for a100-year flood entering the reservoir.
2. Route the computed flood hydrograph through the reservoir to determine the maximum level to which the water surface in the reservoir will rise during passage of the flood and the maximum rate at which flood waters are discharged to the flood channel.
3. Assess the adequacy of the provided reservoir volume and the flood channel capacity.

However, the task is significantly complicated by the following:

1. A significant amount of debris would be carried by the incoming flood and must be deposited and contained in the reservoir.
2. There are no streamgages on the stream channel and USGS peak-flow records from an adjoining gaged basin must be used in the analysis.
3. The peak flows resulting from the most severe storms to have occurred in the immediate area were estimated from field surveys using slope-area or slope-area-conveyance calculations.
4. A large residential development is being constructed downstream from the dam which would contribute significantly to the local tax base. Construction of this development has been approved by both the local county and community governments.

Studies involved in the computation of the 100-year flood hydrograph have been performed by several entities both private and public. The results show that the acceptance or rejection of the estimated (ungaged) peak flows for a severe storm which occurred in 1969 is critical to assessment of the adequacy of the project to fulfill the design criteria of providing protection to downstream areas during passage of floods up to and including the 100-year flood. If the estimated peak flow for the 1969 flood is rejected the project appears to meet minimum requirements. However, if the estimated peak flow for 1969 is accepted, the project does not meet its design requirements and risk to downstream inhabitants and developments is greater than projected in the project design.

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A further complicating factor is that the USGS has undertaken a program to review its peak flow estimating procedures and historical flood peaks that have been so estimated in the past. In the opinion of the USGS investigators, the procedures used to estimate the 1969 peak flow were flawed and that this historical peak flow should be "Discredited." Unfortunately, for the people living downstream of this project, the USGS does not accept any responsibility to make any further effort to estimate just what the magnitude of the1969 flood actually was. By discrediting the estimated peak flow and failing to make a new and better estimate the USGS essentially ignores the fact that the 1969 storm was probably the most severe storm on record in that area.

The preceding scenario is essentially a case of the syndrome "That Flood is Just too Big." Whether or not the parties involved have experienced political pressure to keep the calculated 100-year flood magnitudes low, or whether the result is simply within agency policy, is immaterial. The effect is the same. The real risk to people living downstream from the project is undefined, but is certainly greater than the intended design criteria for the project.

I have rambled on in this dissertation, but my point is this. Integrity and Ethics are a vital part of the practice of any hydrologist or hydrologic engineer. The situation is particularly difficult in the practice of hydrology, since the consequences of our actions can seriously affect innocent people, and the effects of our pronouncements, right or wrong, may not be known for a long time if ever. In the meantime life goes on.