Background reading for the

2004 Assembly

of the

Gilbert F. White National Flood Policy Forum

Reducing Flood Losses: Is the 1% Chance (100-year) Flood Standard Sufficient?

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About the Gilbert F. White National Flood Policy Forum

To facilitate national policy discussions on important floodplain management issues, the ASFPM Foundation sponsors gatherings of leading experts in the field of flood policy and floodplain management. These Forums develop policy recommendations and establish an ongoing record of flood policy issues and directions for the future. The Forums have been named in honor of Gilbert F. White, the most influential floodplain management policy expert of the 20th century. The Forums are not only a tribute to his work, but also a recognition of the success of his deliberative approach to policy analysis and research.

Periodically the Forum will explore one pressing national flood policy issue by facilitating a dialogue among about 50 topical experts, representing various stakeholders, including government, industry, and academia. The goal of each Forum will be to provide recommendations for policies that will reduce the human casualties and economic losses associated with flooding, as well as policies to protect and enhance the natural and beneficial functions of floodplains.

The discussions and recommendations for action and research formulated at each Forum will be summarized and distributed as a report by the ASFPM Foundation.

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INTRODUCTION

Why Examine the 1% Chance Flood Standard?

The United States and much of the developed world use the 1% chance flood standard as a basis for identifying, mapping, and managing flood hazards. Agencies like the U.S. Army Corps of Engineers, Natural Resources Conservation Service, Bureau of Reclamation, Tennessee Valley Authority, and others have used this standard for design of structural and nonstructural flood control projects for over 50 years. The National Flood Insurance Program and most states and local governments use the 1% chance flood as a minimum standard for floodplain management, mapping, and mitigation.

The 1% annual chance base flood standard (100-year flood) was established at the recommendation of a group of experts convened by the U.S. Department of Housing and Urban Development when it was charged with administration of the new National Flood Insurance Program (created with the 1968 passage of the National Flood Insurance Act). The 100-year flood level was selected because it was already being used by some agencies, and because it was thought that a flood of that magnitude and frequency represented both a reasonable probability of occurrence and loss worth protecting against and an intermediate level that would alert planners and property owners to the effects of even greater floods.

In passing the National Flood Insurance Act of 1968, Congress intended continuing studies of flood hazards to provide for a constant reappraisal of the program and its effect on land use requirements. In the intervening years, ways to improve upon the 1% chance standard were occasionally considered, including a 1976 National Academy of Sciences study of incorporating expected probabilities into the flood studies conducted for riverine communities, and a 1983 report by the Presidential Task Force on Regulatory Relief, which concluded that no better alternatives to the standard were available and that there was no justification for the expense of converting to another standard. Both of these efforts were undertaken in response to fairly narrow concerns: the first was controversy about the uncertainties in data on flood discharges, and the second was the Reagan Administration's initiative to reform regulatory programs.

One compelling reason, therefore, for examining the 1% chance flood standard now is that, after about 35-years of experience of using it, there has been no serious attempt to evaluate the standard itself or consider whether it is helping to meet national policy goals—as good practice would dictate and Congress clearly expected. An independent assembly of the nation's floodplain management experts, aimed at examining whether the 1% chance flood standard is still a solid basis for mapping, management, and other activities, is overdue.

Second, concerns are continually expressed about the adequacy and appropriateness of the 1% chance flood standard.

- Floods appear to be getting bigger and causing more damage than anticipated, making it seem as though a higher standard should be used.

- The calculated expected flood depths and the extent of flood reach as depicted on maps are regularly demonstrated to be inaccurate in specific situations, making a range of protection seem more sensible than a single level.
- There are numerous examples of localities' using more accurate techniques, raising the protection level, adding margins of error, and applying tighter restrictions in order to reduce their flood losses—all suggesting that the existing standard may be insufficient in a number of ways.
- Advanced geospatial technology, modeling techniques, and other tools not even dreamed of three decades ago call into question the wisdom of clinging to a standard that was designed without the luxury of those abilities.
- Recent successes in highly accurate measurements and estimates of expected flood levels on a site-specific basis raise the tantalizing possibility of not using a single standard at all, but rather establishing protection techniques on a case-by-case basis.

Most tellingly, despite all the effort nationwide to stem them, flood losses continue to rise, reaching an average of $6 billion annually at the turn of the millennium—suggesting that improvements need to be made in one or more aspects of the nation's approach to managing its flood hazards.

The 2004 Assembly

The first annual assembly of the Gilbert F. White National Flood Policy Forum will address the usefulness of the 1% chance flood standard. The assembly will be formed of about 75 nationally known experts in all aspects of flood hazard management, who will apply their knowledge and experience to a fresh consideration of the appropriateness and sufficiency of the existing 1% standard in furthering national goals and in providing a basis for effective flood hazard management. Over 40 brief invited papers on this topic have been collected within this document, roughly grouped into four broad perspectives. These four groups of ideas also will form the framework for background presentations and discussion at the Forum assembly.

1. **History and Use of the 1% Chance Flood Standard**
   Historical background on how the 1% chance standard was established and how it has been used. What perspective on the standard do other countries bring? Forthcoming evaluation of the standard.

2. **Tools and Technology as applied to the 1% Chance Flood Standard**
   Do new techniques for modeling, mapping, data gathering, analyzing risk, etc. offer a more accurate estimate of the 1% risk? Improve the credibility of the risk prediction? Increase our ability to protect to that risk? Do they improve our ability to manage to any standard? What are their potentials and limitations?

3. **Implementation of the 1% Chance Flood Standard**
   How the 1% chance standard is or is not implemented, exceeded, or refined in various flood-related programs (by states, localities, federal agencies, the private sector). If the 1% chance standard is preserved, how could it be better implemented both in and out of the NFIP? What are the implications of a possible change in the 1% chance standard for those programs and related interests?

4. **Societal Implications of the 1% Chance Flood Standard**
   What are (and will be) the social implications of the 1% chance standard? Has it stood up legally? Are there better ways to convey an understanding of risk—or to manage it— given cultural perceptions, economic goals, and private interests?

Preliminary Agenda

Tuesday September 21

2:00 PM **Welcome**—Bill Hooke, Natural Disasters Roundtable
Larry Olinger, ASFPM Foundation
Self introductions, explanation of process—Larry Larson, ASFPM

3:00 5:00 **Setting the Stage—**Larry Larson, moderator
Presentations on each of four major themes, with time for discussion

- History of use of 1% standard—Gerry Galloway, Titan Corp
- How does technology affect use of the 1% standard?--David Ford,-David Ford Consulting Engineers Inc.
- Implementation of the 1% chance standard—Chad Berginnis, Ohio Dept. of Natural Resources
- Societal implications of the 1% chance standard or changes in it—Dennis Mileti, Natural Hazards Center

5:00-7:00 **Reception**
With the help of beverages and hors d'oeuvre, participants can mingle among stations matching the four main topics (above) to interact and provide additional thoughts.

Wednesday September 22

8:30-9:00 **Opening remarks, summary of previous evening's discussions**—
Gerry Galloway and Doug Plasencia, AMEC Earth and Environmental

9:00- 10:40 **Lessons learned from the past**
Mike Armstrong, ICF Consulting, Gerry Galloway, Doug Plasencia, facilitators
The assembly will split into three groups to consider the following questions:

1. What is the purpose of setting a standard?
2. How well has 1% standard met that purpose , and can it continue to do so (considering technology, policy, legal considerations, and implementation issues)?

11:00-12:00 **Feedback session 1—**Report from a selected representative of each group, with discussion from the assembly

12:00-1:00 **Lunch (provided)**

1:00-2:00 **Future options to achieve flood loss reduction**
Mike Armstrong, Gerry Galloway, Doug Plasencia, facilitators
Three groups will consider the following questions:

1. What are the options for change (considering technology, policy, legal considerations, and implementation issues)?

2. What are the obstacles to change (considering the same factors)?
3. What roles can/should be played by local, state, and federal governments, non-governmental organizations, and the private sector?

2:00-3:15 **Identifying Next Steps**
This facilitated plenary discussion will explore these questions:
1. What are the best options for a standard?
2. What don't we know to make them work?
3. Where are the gaps in research, data, and implementation?

3:15-3:30 **Wrap up**—Larry Olinger and Larry Larson
Identify next steps for the ASFPM Foundation, the ASFPM, and others.
Topic for next year's Assembly?

Part 1

History and Use of the 1% Chance Flood Standard

HISTORY OF THE 1% CHANCE FLOOD STANDARD

Michael F. Robinson
DHS/FEMA

The following discussion is based on information obtained from publications and documents in Department of Homeland Security/Federal Emergency Management Agency files. Only limited information is available in those files on the history of the 1 percent chance flood prior to the establishment of the National Flood Insurance Program (NFIP). I used the term "100-year flood standard" in place of "1 percent chance flood standard" where appropriate to reflect the terminology that was in use at the time.

Evolution of the 100-year Flood Standard

Prior to the 1950's and 1960's the primary governmental response to floods was structural flood control and the only flood standards in use were the design standards for those projects. The Tennessee Valley Authority (TVA) used the "maximum probable flood" and the U.S. Army Corps of Engineers (USACE) used the "standard project flood" as their design standards. As these agencies began moving toward nonstructural floodplain management, there was a recognized need for a different standard that conveyed a level of flood risk that was more appropriate for land use planning and regulation by communities and more meaningful for individuals.

Flood information was initially provided to communities and individuals based on the historical flood of record. However, it was generally recognized that this flood was more a matter of chance and did not adequately reflect the risk of flooding for an area. When TVA began its nonstructural community flood damage prevention program in 1953 it adopted as its standard a "regional flood" which was estimated to be on the order of a 50-year flood or greater. As USACE began to provide floodplain management assistance to communities under the Flood Control Act of 1960 it adopted an intermediate regional flood that approximated the 100-year flood as its standard for nonstructural activities. By the early 1960's, both USACE and TVA recognized the need for a uniform standard and agreed on the 100-year standard. The few state floodplain management programs that had been established by the late 1960's generally also adopted the 100-year standard.

Several other standards were also in use during this period. The Connecticut Resources Commission began to use 5-7 times the mean annual flood as a standard. This equated to between a 35- and 150 year level of protection, depending on the watershed. Their reason for adopting this standard instead of the 100-year flood or some other frequency-based standard was that there was no uniform method for determining flood frequencies. Other standards that were in use at this time include the Soil Conservation Services (SCS) watershed protection program that used the 25-year flood in rural areas and the 100-year flood in urban areas and the U.S. Geological Survey that provided flood data based on the 50-year flood. USGS was initially reluctant to provide information on the 100-year flood because it required extrapolating data beyond experience.

By the late 1960's government agencies seemed to be coalescing around the 100-year standard as the standard for floodplain management. However, other standards were still in use and there was still no national standard that was agreed to by all agencies.

Executive Order 11296

In August 1966, the President issued Executive Order 11296 on *Evaluation of Flood Hazard in Locating Federally Owned or Financed Buildings, Roads, and Other Facilities and Disposing of Federal Lands and Properties*. E.O. 11296 directs Federal agencies to take flooding into account when making decisions, but contains no standard level of protection. Federal agencies were to develop joint implementing procedures and regulations. This was a several year process and U.S. Water Resources Council did not issue final guidelines for evaluating flood hazards until May of 1972. These guidelines recommended that agencies use the 100-year flood as the "basic flood" to identify and evaluate flood hazards, but provided for the use of smaller and larger floods as appropriate.

Adoption of the 100-year Standard by the National Flood Insurance Program

The National Flood Insurance Act of 1968 that established the National Flood Insurance Program (NFIP) directed U.S. Department of Housing and Urban Development (HUD) to establish floodplain management criteria and to designate flood hazard areas, but was silent on the standard that was to be used. HUD contracted with the University of Chicago's Center for Urban Studies to conduct a seminar to make recommendations on the floodplain management criteria that HUD was to develop. This meeting, chaired by Gilbert White, was held from December 16-18, 1968 and is commonly referred to as the Chicago Seminar. The report recommends that the regulations apply in "that portion of the flood plain subject to inundation by the 100-year flood".

One of the work groups at the seminar had the responsibility of developing hydrologic standards for the identification of floodprone areas and for regulations. Nick Lally included his recollections of this group's deliberations in a paper prepared for FEMA in1982.

> "The group deliberated about 1 ½ days and finally recommended that the 100-year flood would be a reasonable level to use in identifying flood prone areas. ...The recommended level was a compromise that all of those present were comfortable with and could support. There was no attempt to make any economic analysis due to the constraints of time."

One member of the group supported the 100-year standard, but felt that local deviations should be allowed. The consensus of the group was that, since the NFIP was a new program that was badly needed, it should not be made more complicated by allowing deviations from the 100-year standard.

On February 27, 1969, HUD's Federal Insurance Administration (FIA) published a proposed rule that contains the first floodplain management criteria developed for the NFIP. This proposed rule does not mention the 100-year flood or any other standard (it may have been too soon after the Chicago meeting for a decision on a standard to be made). The June 18, 1969 Final Rule defines "Floodplain having special flood hazards" as the 100-year floodplain for mapping purposes, but only requires that communities "should take into account the relation between first floor elevations and the anticipated level of the 100-year flood" in developing their floodplain management measures. It was not until the June 9, 1971 proposed rule and September 10,1971 final rule that the NFIP specifically tied the regulatory requirements of the program to the 100-year flood standard.

With its adoption and use by the NFIP, the 100-year flood standard became the de facto national standard for floodplain management. Since most floodplain mapping was now being done in support of the NFIP and communities had to meet NFIP minimum requirements to be eligible for flood insurance, the 100-year flood standard soon replaced any other standards that were still in use.

Senate Hearings on the Flood Disaster Protection Act of 1973

The key issue at the U.S. Senate Committee on Banking, Housing, and Urban Affairs hearing on the Flood Disaster Protection Act of 1973 was the NFIP's adoption of the 100-year standard and not the imposition of the prohibitions on federal assistance in designated floodplains or the mandatory flood insurance purchase requirement. Much of the opposition to the standard came from communities. Most cited the perceived devastating economic impacts on communities of using this large of a flood to designate floodplains and as a basis for mandatory purchase and floodplain management regulations. For example the City of Savannah testified that they had only sustained $10 million in damages since 1900, yet it would cost $100 million to $700 million to meet floodplain management requirements based on the 100-year standard.

Alternatives that were discussed at the hearing include the 50-year standard, the historical flood of record, and a flexible standard that would recognize the differences in damages that would occur under a variety of flooding condition. FIA and USACE both prepared papers supporting of the 100-year standard that were submitted for the record. These papers both argued that the 100-year standard was a reasonable standard that provided the proper balance between the competing needs for economic development and flood protection and that there was a need for a uniform standard to administer the NFIP. Gilbert White, Jon Kusler and James Wright testified on a panel in support of the standard with Jon Kusler raising the additional concern that the 100-year standard may not be restrictive enough.

In the Committee Report, the Committee "agreed that the 100-year standard or the flood that has a one percent chance of occurrence is reasonable and consistent with Nationwide standards for flood protection". In retrospect this endorsement by the Senate Committee settled the issue of the 100-year standard even though there continued to be challenges to its use. For example, the issue was again raised in hearings on amendments to the National Flood Insurance Act in 1974. The 1974 amendments also are the first time the 100-year flood is specifically mentioned in NFIP legislation although only in the context of limiting flood insurance premiums where adequate progress had been made on constructing Federal flood control projects.

Base Flood

During this period concerns were raised that the term 100-year flood was misleading and that other terminology should be used. In an October 15, 1976 letter the Water Resources Council's Hydrology Committee recommended that Federal agencies use descriptive terminology for future flood events that would convey to the public their probabilistic character. In keeping with the discussion that preceded this recommendation, HUD/FIA's March 26, 1975 proposed rule and October 26, 1976 final rule introduced the terms "base flood" and "base flood elevation" and began to phase out the use of the term "100-year flood". Base flood was defined was defined as "the flood having a one percent chance of being equaled or exceeded in any given year." The term 100-year flood is still used in the NFIP as a colloquial term and is still used on flood hazard maps, but does not appear in the floodplain management regulations.

In the national hearings and comment period held during the development of the October 26, 1976 final rule, there was again discussion on the NFIP's use of the 100-year standard. Comments were divided, some wanting a less restrictive standard, others advocating elevating structures to a height exceeding the base flood elevation, and still others wanting to allow no new construction in the floodplain. In the final rule the FIA Administrator stated that he continued to believe that elevating to above the base flood elevation was reasonable and no changes were made to the standard.

Executive Order 11988, Floodplain Management

On May 24, 1977, President Carter issued Executive Order 11988, *Floodplain Management.* The Executive Order directs Federal agencies to use HUD (now FEMA) maps to determine if an action will occur in the floodplain and to adopt regulations and procedures consistent with those promulgated under the National Flood Insurance Program. This in effect established the 100-year standard as the minimum for evaluation of all Federal actions. The U.S. Water resources Council *Floodplain Management Guidelines for Implementing E.O. 11988* introduced the concept of providing 500-year protection to "critical actions". "Critical actions" include those actions for which even a slight chance of flooding would be too great. Examples include hazardous materials, hospitals, and emergency services.

The Presidents Commission on Housing, the Vice Presidents Task Force on Regulatory Relief, and FEMA's Report on the 100-year Base Flood Standard

The Presidents Commission on Housing was established in June of 1981 and charged with reviewing all existing Federal housing policy and programs and assessing factors that contribute to the cost of housing. Much of the focus of the commission was on removing regulatory barriers and not on issues such as providing adequate flood protection to housing. The Commission provided a forum for HUD and others to again raise issues associated with the 100-year standard. The Commission recommended reevaluating and revising the 100-year standard to "take into account water height, velocity of flow, frequency of flooding, quality of floodwater (sediment and debris), historical flood-loss experience, socioeconomic costs (both in terms of damage and of removal of land from development), and maximum average annual damages…" They suggested substituting a risk-based approach based on an acceptable level of flood damage to structures for the 100-year standard.

Based on the recommendations of the Presidents Commission on Housing, the Vice Presidents Task Force on Regulatory Relief included the 100-year standard and Executive Order 11988, *Floodplain Management* on its list of Federal regulations and policies that might impose severe hardships on States, local entities, and citizens.

The Office of Management and Budget (OMB) then directed FEMA to undertake a review of the 100-year base flood standard and Executive Order 11988. FEMA reviewed the history and usage of the standard and conducted a formal solicitation of comments from Federal agencies, the Governors and others. Again, no effort was made to analyze the standard in terms of costs and benefits. Federal and State agencies, communities, and individuals submitted 105 comments on the 100-year Base Flood Standard. The responses were overwhelmingly in support of retaining the 100-year base flood standard. FEMA submitted its report to OMB in September of 1983. Findings and conclusions were:

- The 100-year base flood standard was strongly supported and being applied successfully by all levels of government.
- No alternatives were identified that were superior to it, and there was no evidence to justify the expenditure of funds that would be necessary to convert to another standard.
- Improvements or refinements in application of the 100-year base flood standard to unique flooding situations could further effect flood loss reduction.

FEMA recommended to OMB that the base flood standard be retained. In a January 6, 1984 letter, OMB agreed with FEMA's conclusions and concluded that "the 100-year base flood standard appears to be working well and, given it's widespread use, it does not appear to be in the public interest to adopt another methodology."

Discussions on the 1 Percent Chance Flood Standard Since 1983

Since 1983, there has been very little discussion on changing the 1 percent chance flood standard to an alternative standard. The standard has been incorporated into policies and programs at all levels of government and any change would be exceedingly costly and disruptive. The need to provide protection to at least the 1 percent chance flood has become almost universally accepted. Communities seldom argue that implementation of floodplain management regulations that use the 1 percent chance flood standard will cause severe economic harm.

Most of the discussion has instead focused on how the standard is applied and, in particular, whether current NFIP minimum requirements are achieving a 1 percent chance flood level of protection. A major concern has been how that the level of protection can deteriorate over time due to factors such as urbanization, coastal erosion, and floodplain encroachment that tend to increase flood risk. The Association of State Floodplain Managers' (ASFPM) "No Adverse Impact" initiative in part is intended to address many of these issues.

Examples of actions that can be taken beyond NFIP minimum requirements to prevent future increases in flood damages include:

- Use of future conditions hydrology, particularly in rapidly urbanizing areas,
- Stormwater management and regulation to reduce increases in run-off,
- Preservation of floodplain storage,

- Designation of zero rise floodways, and
- Use of Freeboard

In addition, there are special hazards that are not adequately addressed by current NFIP mapping and minimum floodplain management standards, such as:

- Areas subject to coastal erosion.
- Coastal AE zones. These are areas outside of the Coastal High Hazard Area (V Zone) that are subject to wave impacts.
- Alluvial fans and similar arid regions flooding.

These issues are not related to adequacy of 1 percent chance flood standard, but instead relate to how the standard is applied.

Finally, there are two situations where there is general agreement that protection to the 1 percent chance flood may not provide an adequate level of flood protection:

- Recognition of levees providing protection to urban development.
- Protection of critical facilities.

These issues were addressed in *Sharing the Challenge: Floodplain Management into the 21st Century* (Interagency Floodplain Management Review Committee, June 1994) written in response to the 1993 Midwest Floods. That report expressed concerns over the residual risk behind levees credited with providing100-year protection. It recommended that the Standard Project Flood be used as the minimum level of protection for urban development and that flood insurance be required behind all levees that provide less than that level of protection. The report also recommended providing a similar level of protection to critical facilities. Residual risk behind levees was also a major issue in the on-going controversy related to the American River levee system in Sacramento, California. This resulted in the report *Flood Risk Management and the American River Basin: An Evaluation* published in 1995 by the National Academy of Science.

NFIP Community Rating System (CRS)

FEMA's strategy to address many of the issues identified in the previous section has been to provide incentives through the National Flood Insurance Program's Community Rating System (CRS) for communities that voluntarily map or regulate to a higher standard than NFIP minimum requirements. Many of the approaches recommended in ASFPM's *No Adverse Impact: A Toolkit for Common Sense Floodplain Management* (2003) are already credited under CRS. In addition, most FEMA guidance that has been issued in recent years not only explains minimum requirements, but also recommends that communities consider adopting more restrictive requirements where appropriate.

NFIP Evaluation

In 1999 FEMA began a comprehensive evaluation of the National Flood Insurance Program (NFIP). The evaluation is being coordinated for FEMA by the American Institutes for Research (AIR). Proposals are currently being solicited for a subcontractor to conduct a study on the 1-Percent Chance Flood Standard. This study will build on the results of the ASFPM Forum and provide an opportunity to follow-up on any issues that are identified. Other studies already underway that may provide information on the adequacy of the 1 percent chance flood standard include studies on:

- Mapping Anticipated Development
- Minimum Building standards
- Environmental and Developmental Impacts of the NFIP
- Actuarial Soundness
- Risk Perception
- Costs and Consequences of Flooding.

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THE EVOLUTION OF THE 100-YEAR FLOOD STANDARD

John R. Sheaffer
Sheaffer International

To best understand how the 100-year flood standard was selected as the regulatory flood, it is necessary to examine the implementation of the National Flood Insurance Act of 1968 (PL90/448 Title XIII), enacted by Congress on August 1, 1968. The Act stated that flood insurance might be made available in geographic areas meeting certain conditions. Also, premiums may be subsidized in areas which exhibit proper land management and use. The Act presented a trade off of a federal public subsidy for local and state floodplain management. One of the purposes of the Act was to authorize continuing studies of flood hazards to provide for a constant reappraisal of the program and its effect on land use requirements. This has not been done.

The Department of Housing and Urban Development (HUD), was selected by Congress to implement the flood insurance program. To do so, HUD contracted with the University of Chicago to develop guidelines, which would provide a structure for the flood insurance program. Research related to flood insurance was assembled and analyzed. About 50 researchers in the field of floodplain management were identified and invited to participate in a floodplain management guidelines seminar. This seminar was held under the auspices of the Department of Housing and Urban Development at the Center for Continuing Education, University of Chicago on December 16, 17, 18, 1968. The result of the deliberations were published in a document entitled, "Report on Flood Plain Management Guidelines Seminar," which was issued in January 1969.

The Seminar developed a series of definitions to be used in implementing a flood insurance program. The first issue debated related to the delineation of the floodplain and the evaluation the floodplain and evaluate the flood hazard. The flood selected would be used to provide a hydrologic basis for a floodplain management program.

In the discussions, references were made to flood used in project planning by the Corps of Engineers, the Tennessee Valley Authority, the American Society of Civil Engineers, and the US Geological Survey. There was much debate over which flood should be used to determine the regulatory area. Terms such as Standard Project Flood, Maximum Probable Flood, Regional Flood, and Flood of Record were discussed. When an effort was made to compare these floods, frequency determinations emerged. It was agreed that frequency determinations should be based upon the Log- Pearson Type III distribution (with the log-normal as a special case) or by alternative studies as outlined in the US Water Reserves Council Bulletin No. 15, "A Uniform Technique for Determining Flood Flow Frequencies." There were few flood records that recorded floods for a 100-year period at any gaging station. Nevertheless, the discussions focused on the selection of a flood frequency determination that would delineate the regulatory area. The 100-year flood emerged as the flood to be used in the flood insurance program. There was no data on 100-year floods, but it was stated that it had "a nice sound" to it and would give an allusion of safety. As a result, all of the definitions developed at the Seminar, e.g., floodway, flood fringe, and regulatory area, were based on the 100-year flood. Also, the communities were to formulate land use regulations for the 100-year flood plain. Each locality was to regulate the extension of public facilities such as streets, sewers, gas, electricity and water in the 100-year floodplain regulatory area.

In recognition of the fact that there were no research findings available on the 100-year flood, the Seminar called for periodic review and adjustments of the appropriateness of the selection. A constant reappraisal of the program and its effects on land use was suggested.

Other questions that were to be investigated as the National Flood Insurance Program progressed included: What is a difference in damages between the 50-year and the 100-year floods? Could a sensitivity analysis indicate if there is a breakpoint in damage frequency relations?

The Seminar concluded with the recommendation that the talents of hydrologists, planners, lawyers, geographers, geologists, economists, political scientists, and sociologists needed to be incorporated in this research undertaking. National seminars and workshops should be regularly scheduled to test ideas and provide the opportunity for the participates to constructively shape the National Flood Insurance Program to reflect actual experience. There would need to be ongoing evaluations of the Program. However, experience shows ongoing research was not a priority in the program. The first Gilbert F. White Forum provides the opportunity to evaluate the 35-year history of the Flood Insurance Program to formulate recommended program adjustments.

WHY THE 100 YEAR FLOOD STANDARD

Richard Krimm

When the National Flood Insurance Act was passed in 1968, it did not contain a directive on how to establish flood zones. This decision was left to the Department of Housing and Urban Development (HUD) to decide.

As a part of HUD, the newly organized Federal Insurance Administration called for a conference of geographers, hydrologists and others familiar with flood plain management at the University of Chicago in December 1969. This group debated various alternatives for a flood standard to be used by the National Flood Insurance Program in identifying the Nation's flood plains. The result was a compromise between the 500 year flood standard and a 50 year or lesser standard. Thus the 100 year flood standard or the flood with a 1% annual chance of occurrence was adopted by the Federal Insurance Administration and was used to identify flood plains, to require land use management in communities participating in the program and as a basis for establishing actuarial insurance rates for new construction in the identified floodplain.

As communities started to enroll in the National Flood Insurance Program, many coastal communities located in southern states challenged the standard while certain states, particularly in the mid west, felt the standard was not sufficient to adequately prevent future flood damage. After the devastation of Hurricane Agnes in 1972, the National Flood Insurance Program was strengthened by the Flood Disaster Protection Act of 1973 (FDPA 73), which required flood insurance as a condition of federal loans or federally backed mortgages in identified flood plains. The FDPA 73 also affirmed in legislation the 100 year flood standard and required the identification of all the Nation's flood plains using the 100 year flood standard as the basis of the identification. Communities participating in the program were required to adopt minimum flood plain management laws for the identified flood plain based on a rather quick identification of the flood plain. Subsequently a more detailed flood insurance study identified elevations, floodways for the riverine communities and velocity zones for costal communities, and provided the information for establishing actuarial rates.

Although the National Flood Insurance Program has been reasonably successful for the thirty-six years of its existence, I think it is time to re-examine the 100 flood standard. Even though I have been retired from involvement with the program for six years, I have watched unrestricted coastal development, the failure of the Federal Emergency Management Agency to publish and adopt regulations based on a coastal erosion study performed by the H John Heinz III Center for Science, Economics and the Environment, as well as the devastation caused by riverine flooding.

If I could go back to the time when I was the Assistant Administrator for Flood Insurance, I would make the following program changes:

1. For coastal communities, I would require the 500 year flood standard, establish higher actuarial rates for the velocity zone and require set backs for coastal erosion.

2. For riverine communities, I would retain the 100 year flood standard, but would require a zero rise in the floodway, instead of a one foot rise, and would look at the effects of future development on the flood plain.

I believe some changes are being considered in the mapping program, which will benefit the National Flood Insurance Program and will have the long term effect of reducing flood damages. However with our increasing population and rapid development there is a need to look at ways to strengthen the National Flood Insurance Program in order to reduce the effects of flood disasters.

THE "BASE FLOOD STANDARD" — HISTORICAL PROSPECTIVE

Francis V. Reilly

Most of my time working at the Federal Insurance Administration (1973 to 1993) was devoted to dealing with the overall management and actuarial aspects of the NFIP. Since 1993, I have maintained an active interest in the Program. At the request of Larry Larsen, ASFPM Executive Director, I have set forth some of my thoughts on the question "Is the 1% chance (100 year) flood standard sufficient?"

I respectfully recommend that in any evaluation of the effectiveness of the current "base flood standard" (1% or greater chance of flooding in any given year) it is necessary to consider the historical purpose and use of the standard.

The selected "base flood standard" was to help ensure that the NFIP met its primary purposes – (1) encourage state and local governments to make appropriate land use adjustments to constrict the development of land that is exposed to flood damage and minimize damage caused by flood losses, (2) guide the development of proposed future construction, where practicable, away from locations which are threatened by flood hazards, and (3) provide an insurance program based on workable methods of pooling risks, minimizing costs, and distributing burdens equitably among those who will be protected by flood insurance and the general public. Additionally, a single standard for the three major components of the NFIP (flood hazard reduction, floodplain management and insurance) was operationally very useful.

The basic tests that should be met in the selection of an effective basic flood standard are:

- The standard has to be acceptable to the scientific community.
- The standard has to be acceptable to Congress and the Executive Branch.
- The standard has to be practical to determine and applied objectively and consistently.
- The standard and its application have to be legally defendable.
- The standard has to result in an NFIP that is fiscally sound.
- The standard should be acceptable to the NFIP stakeholders.

The Standard Has To Be Acceptable To The Scientific Community

The four Federal agencies with major responsibility for constructing flood prevention works or gathering and developing flood information for a number of studies (prior to enactment of the NFIP in 1968) identified flood risk zones by recurrence intervals. Five risk zones (recurrence intervals of 0-5 years, 5-10, 10-25,

25-50, 50-100, and 100+ years) were used in a series of sensitivity analyses. These calculations (contained in the 1966 HUD feasibility study required by PL 89-339)) showed the extreme differences in pure loss costs for the five risk zones. Given these data and other existing information, it is not surprising that a group of scientists and other experts in 1970 recommended the 1% or greater chance of flooding (100 year flood) as the "base flood standard".

The Standard Has To Be Acceptable To Congress And The Executive Branch

Given this body of data and the informed judgement of experts, George K. Bernstein, Federal Insurance Administrator, was able to overcome attempts to use a lesser standard (e.g. 50-yr.).

The 1973 enactment of PL 93-234 (1972 Act, as amended) affirmed the use of the 1% or greater chance of flooding (100-year flood) for identifying special flood hazard areas. Most notable, the Act required community participation, and/or property owner flood insurance purchase as a pre-requisite for eligibility of many federal programs (including the politically sensitive disaster assistance programs).

The 1973 NFIP regulations are published with performance standards keyed to the 1% or greater chance of flooding (100-year flood) “base flood standard”.

Issued in 1977, Executive Order 11988 – Floodplain Management, specifically defines the floodplain and the base flood in terms of the 1% or greater chance of flooding (100-year flood).

Since then, numerous Congressional oversight hearings and other studies have reaffirmed the 1% or greater chance of flooding (100-year flood) “base flood standard”. In the early 1990’s, Congress conducted the most comprehensive review of the NFIP since the passage of PL 93-234 (at least 10 oversight hearings). The passage of the NFIP Reform Act of 1994 in effect reaffirmed the “base flood standard” by including provisions dealing with updating FIRM’s, codifying the Community Rating System to provide community benefits for exceeding the NFIP minimum requirements, and providing penalties to assure financial institutions carry-out their insurance purchase responsibilities. *Comment: The Conference Report statements on Sec. 522, 524, 527 and 575 specifically mentions the SFHA using terms such as "clarifies", "to ensure", "reinforces", "to increase compliance".* Although the Program has its critics, they have never mounted a convincing attack on the “1% base flood standard”.

The Standard Has To Be Practical To Determine And Applied Objectively and Consistently

I believe the NFIP historical experience supports the conclusion that the “base flood standard” is practical and is applied objectively and consistently. The hydrologic method permits review and adjustments essential as new data and new technology becomes available.

In spite of deficits, Congress in the last four years has appropriated funds for flood map modernization. The Administration’s funding of flood hazard identification with policyholder funds began in the 1980’s over the objection of House Subcommittee on Policy Research and Insurance. I believe the Administration’s reversal of this policy in the last few years is evidence that the use of the “base flood standard” for flood hazard identification is practical and considered to be applied objectively and consistently. Section 107 of the Insurance Act of 2004 addressing geospatial digital flood hazard data recognizes the practical use of new technology in determining the special flood hazard area.

Although the Program has its critics about the quality of the flood maps, they rarely or ever have attacked the “base flood standard”.

The Standard And Its Application Has To Be Legally Defendable

The State Supreme Courts and US Supreme Court seems to consistently hold that an essential nexus exists between floodplain management requirements within the 100 year flood plain and legitimate state interest.

The Standard Has To Result In an NFIP That Is Fiscally Sound

Since 1986, the flood insurance policyholder funds are virtually the sole source of funds for supporting the flood hazard identification, floodplain management and insurance functions of the NFIP. With policyholder premiums of $23 billion from 1987 to 2003, the NFIP has been self-supporting over this timeframe. Only the recent flood map modernization appropriations totaling about $500 million has been funded by the taxpayer.

FEMA estimates that flood damage is reduced by over $1.1 billion a year through communities implementing sound floodplain management requirements. Additionally, buildings constructed in compliance with NFIP building standards incur approximately 80 percent less damage annually than those not built in compliance.

FEMA estimates that every $3 paid in flood insurance claims saves $1 in disaster assistance payments. For the period 1987 to 2003, the NFIP has paid over $13.3 billion in flood losses. This translates to an estimated $4.4 billion savings in disaster assistant payments.

The use of the "base flood elevation" standard results in affordable flood insurance premiums. The current average annual actuarial premium for the A Zones is about $325 and about $1,250 for the V Zones. The NFIP actuarial ratemaking approach has allowed the NFIP to cross subsidize (out of the loss and contingency provisions in the collected actuarial premiums) not only the Pre-Firm risks, but also fund NFIP mitigation and flood mapping costs.

If a lower base flood standard, such as the 50 year or 2% or greater chance of flooding in any given year, had been adopted the estimated average premiums would have been over $600 and $3500 respectively. I believe flood insurance costs this high would make it difficult politically to enact and enforce the mandatory purchase requirement or to fund NFIP mitigation programs out of collected premiums. *Comment: These are very conservative estimated average premiums for a 50 year standard. The PriceWaterhouse Study of actuarial rating of 7,628 PRE FIRM buildings resulted in an average premium of $1,128 for A & V Zones combined. Prior to the Forum, FEMA will provide more accurate estimates using their computerized rate model.*

The Standard Should Be Acceptable To The NFIP Stakeholders

Stakeholders seem to accept the "base flood standard", although it appears many do not understand or perceive the flood risk reduction benefits implied in the standard.

“Is The 1% Chance (100 Year) Flood Standard Sufficient?”

Having outlined what I believe to be a good case justifying the selection of the current “base flood standard”, does not mean it should not be further optimized. However, in attempting to do so, consideration of the above mentioned historical and political implications is a must.

THE DURABILITY OF THE ONE% /100-YEAR FLOOD STANDARD DESPITE ITS MANY FAULTS

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The One Percent/100 Year Flood Standard is perhaps unique in the annals of resource management policy for its durability over several decades and its widespread acceptance in federal and state floodplain management programs despite chronic griping and hand-wringing by three generations of floodplain managers. Its very bifurcated name hints at the perpetual state of unease of flood professionals at the use of a single label. Why confuse the public with only one term, when two confusing terms will suffice!

How many presentations at flood conferences and natural hazard workshops have bemoaned the shortcomings of this much maligned term and concept? We remind each other at every opportunity that the "One percent/100 Year Flood" is statistically more uncertain than it sounds, that such events occur regularly in rapid succession (usually in Houston), and that much larger, albeit less frequent events do much more damage. We admit we can't readily know such an event for sure when it occurs. And with the passage of time and the quest of Walmart to pave the earth for parking lots, it will surely be worse the next time it happens (especially in smaller watersheds). Or rather, it will happen more often and therefore become a "Five percent/20 Year Flood." Everything built to withstand the One Percent event therefore is endangered when a new, improved, larger "One percent Flood" occurs.

We also recognize that telling people they are within the One-Percent Floodplain does not phase them very much. They have a much higher probability of dying than that over the coming year. And they are preoccupied with more publicized, if not more serious, threats to their health and wealth such as terrorism, West Nile Virus, Lyme Tick Disease, and email viruses. It helps to explain that the flood risk is only that low at the outer margins of the One Percent Floodplain, and that the risk increases the closer you are to the stream, lake, or tidewater posing the flood threat. But official floodplain maps including NFIP rate maps do not convey that message.

On the open coast, the risk of flooding from storms and hurricanes is subsumed into the total palette of threats including waves, wind, rain, erosion, and difficulty of evacuation, in addition to high water levels per se. Some years ago an expert committee of the National Research Council pointed out that coastal storms not only elevate water levels through "storm surge" but they also generate huge waves that reach far above the estimated "stillwater" one-percent flood elevation. As a result, most NFIP maps for open coast shorelines now include "wave heights" data which is considered in setting minimum elevations for structures.

Given that realization, it is interesting that NFIP maps still do not incorporate data on coastal erosion hazards. Veterans like Ed Thomas and I remember the February Northeaster of 1978 which wiped out much of the shoreline homes in places like Scituate, Massachusetts and carried away Henry Beston's "Outermost House" on Nauset Beach, Cape Cod. That was perhaps the first major coastal disaster where the issue of rebuilding in areas subject to chronic erosion (like Pegotty Beach in Scituate) was raised. Of all people, the state's champion for more sensible redevelopment was none other than John Kerry, then the Massachusetts Lieutenant Governor, under Michael Dukakis. Not much was achieved then; Pegotty and similar beaches were rebuilt with much larger homes that were damaged in later storms. But Kerry carried the erosion management issue deep in his subconscious, and emerged a decade later as the sponsor of a series of bills to incorporate erosion data into NFIP floodplain maps. That effort was based on a 1990 report of a National Research Council committee (that included Steve Leatherman, Dave Owen, Martin Jannereth, Bob Dean, and me among its members) urged erosion to be reflected both in coastal flood hazard maps and in the NFIP insurance rate structure.

But unlike wave heights, erosion proved to be a hard sell. Coastal property organizations from Maine to Florida, with the Fire Island Association as their Charleton Heston, lobbied frantically against any limits on the rights of property owners to rebuild *in situ* after a coastal storm—of course using flood insurance proceeds when available. Senator Kerry's office called me to ask how he should respond to claims that publication of erosion data would devalue coastal property, allegedly comprising a "taking without compensation" in violation of the Fifth Amendment. Playing the role of Oracle of Delphi, I suggested that Kerry respond that it is the responsibility of government to protect public safety and investment by publishing creditable scientific data available to it. Otherwise, the U.S. Geological Survey should be enjoined from publishing earthquake hazard and landslide maps, and indeed, how then could FEMA even publish its regular flood hazard maps? (In my book *Disasters and Democracy,* I quote Kerry quoting me in the *Congressional Record* – will he remember that when he is elected President?). Alas, the "Gingrinch that Stole Congress" carried the day and erosion standards never joined wave heights as amplications of the basic one-percent floodplain in coastal areas.

But despite these and other shortcomings, the One Percent/100 Year Flood standard has certainly withstood the test of time. No one except Gilbert White knows precisely when and how it originated. One assumes that he and Jim Goddard thought it up at the time of the early TVA floodplain management program in the late 1950s, long predating the NFIP. The Corps of Engineers used a different term—the Standard Project Flood—as the design baseline for its flood control projects. This had the advantage of being statistically vague and therefore impossible to question. But when the Corps began to do floodplain delineation in the 1960s, they moved toward the 100 year flood terminology. Perhaps the crowing achievement of the short-lived U.S. Water Resources Council, with Frank Thomas and Leo Eisel at the helm, was to gain acceptance of the One Percent/100 Year Flood as the standard for flood hazard mapping and mitigation across the entire federal government. Then the newly born Association of State Floodplain Managers, with Larry Larson at the helm, adopted that as the nearly universal standard for state flood programs, thus enshrining it in law, regulations, and policy manuals for all eternity.

The National Flood Insurance Program, of course, uses a different and even more cryptic term: the "Base Flood." But as defined in NFIP regulations at least since 1979, the Base Flood miraculously is defined as (three guesses) the One Percent Flood.

The terminology of environmental law and resource management includes many terms less precise and more difficult to apply than the "one-percent flood." "No Net Loss" in wetlands law and "Best Available Technology" in air quality law come to mind. But few terms have endured the ravages of professional misgivings, public criticism, and scientific uncertainty, yet continue to undergird federal, state, and local programs as has this one. The One Percent/100 Year Flood, warts and all, is a durable and useful political compromise between worst case and routine flood hazards. As such, it can be expected to survive in the inner sanctum of floodplain management indefinitely.

NOTES ON PROBABILITY ANALYSIS AND FLOOD FREQUENCY STANDARDS

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In the 1914 *Transactions of the American Society of Civil Engineers*, engineer Weston D. Fuller attempted to apply probability principles to flood problems. He suggested that *frequency* was an essential component in determining the magnitude of the maximum flood for a river. Other engineers had privately discussed the idea earlier. Fuller himself acknowledged that Allen Hazen had first suggested using the element of time intervals in a formula in a letter to him in 1910. Eminent hydrologist Robert Horton, one of the discussants of Fuller's paper, claimed that George Rafter of the U.S. Geological Survey had suggested the idea to him as early as 1896. That same year, Horton had written an analysis of rainfall and runoff in the Upper Hudson Drainage Basin that used probability theory, but that study did not appear in any professional publication. Fuller's was the first essay to appear in an engineering transaction, and the first to apply an impressive amount of empirical data to the problem. Therefore, he rightly deserves credit for introducing probability theory into American hydrology.[1]

As early twentieth century engineers realized, probability--and probability curves--could be expressed in several ways. Allen Hazen employed duration curves in an article which appeared in the same volume as Fuller's.[2] These curves show a particular percent of time that any discharge is equaled or exceeded. For example a duration curve will show that for a particular stream over a given amount of time the discharge equaled or exceeded 2,000 cfs 85 percent of the time and 4,000 cfs 28 percent of the time. It is all but impossible to track the first use of duration curves, although eminent American engineer John R. Freeman credited Clemens Herschel with developing the idea, evidently referring to an article on "The Gauging of Streams" that appeared in the 1878 ASCE *Transactions*. Freeman himself used duration curves in his study of New York City's water supply in 1900. In the first decade of the twentieth century, several other engineers also used duration curves.[3]

The California Department of Public Works modified duration curves in a way that had lasting significance. In a bulletin published in 1923, the Department plotted the probable frequency of floods occurring in 100 years for 140 rivers or groups or rivers within the state (or, for example, a ten year flood would have a frequency of 10 per hundred years). At first called the "California Method," it became a popular and lasting way of characterizing flood threats. In 1930, Allen Hazen suggested that the term one percent flood be used instead of hundred year flood. The change clarified that a one percent chance existed that the flood would occur in any one year. Using this approach, a 25 year flood would equal a four percent flood. Although

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* Parts of this paper appeared in the author's article "Probability Analysis and the Search for Hydrologic Order in the United States, 1885-1945," *Water Resources Impact* 4, 3 (May, 2002): 7-15. This work is from an ongoing study of the history of hydrology in the United States.

many professional hydrologists supported Hazen's proposal, the term "hundred year flood" gained wide popularity and led to much misunderstanding among the public.[4]

Experienced hydrologists understood the mystical power of numbers to generate unsupported confidence, and they insisted on the importance of common sense and experience in developing frequency curves. In the middle of the 1930s, Thorndike Saville, Associate Dean of the College of Engineering at New York University, commented in a U.S. Geological Survey report:[5]

> It is believed that none of the methods thus far presented for estimating frequency of flood magnitudes offers more than an approximation for the guidance of an engineer's judgment. The method, the period, and the character of the data (whether annual floods, daily flows, flood peaks, etc.) may all produce results that are of considerably different magnitudes. In the last analysis the engineer should satisfy himself that he has used an adequate number of methods, whether mathematical, or otherwise, which have real support from either theory or experience, and then form his own judgment after taking into account his knowledge of the character and accuracy of the data, the purpose for which the estimate is made, and other pertinent conditions.

In that same report, Professor J. J. Slade, assistant professor of engineering mechanics at Rutgers University, similarly observed: "In the writer's opinion the statistical method, in whatever form employed (graphic or analytical), is an entirely inadequate tool in the determination of flood frequencies. When used in conjunction with nonstatistically inferred data, however, it may attain a high order of precision."[6]

Determinations about flood frequency became more urgent after the nation experienced several disastrous floods in the mid-1930s. During March 9-22, 1936, heavy rains drenched the northeastern United States. The U.S. Geological Survey reported, "The depths of rainfall mark this period as one of the greatest concentrations of precipitation, in respect to time and magnitude of area covered, of which there is record in this country."[7] Already swollen with runoff from winter precipitation, rivers raged from Maine to Maryland and west to Ohio. In New England, huge chunks of ice added to the damage. According to historian Joseph L. Arnold, "Billions of tons of water poured into farmhouses, village, towns, and large cities."[8] In the nation's capital, Civilian Conservation Corps personnel frantically built sandbag barricades around the Lincoln and Washington Monuments and the Navy's administration building. Congressmen looked out their office windows to see the Potomac River at 19.8 feet about flood stage, with the city's riverfront parks and grounds inundated with brown water. Firsthand, they learned about flood devastation.[9]

Legislation making flood control a federal responsibility had been introduced into Congress the previous year, but had died among accusations of useless and questionable projects, of pork barrel legislation at its worst. However, the 1936 floods almost guaranteed that some sort of legislation would pass. Partially to avoid pork barrel charges this time around, the bill's principal sponsor, Senator Royal S. Copeland of New York, eliminated any projects that did not carry a favorable benefit for flood control alone--without the addition of hydropower or other benefits--nor did not have the Chief of Engineer's approval. Although there was much discussion, this time the legislation met success. This act was not the first federal flood control legislation; that distinction went to a 1917 act that authorized flood control only on the lower Mississippi and Sacramento rivers. However, it was the first to declare "that is it is the sense of Congress that flood control on navigable waters or their tributaries is a proper activity of the Federal Government in cooperation States, their political subdivisions, and localities thereof."[10] The act authorized some 211 flood control-projects--principally levees, reservoirs, and drainage channels--at an estimated cost of approximately $300 million. They were located in thirty-one states and would affect nearly every state in the country.[11] Together, they were designed to protect people and property on approximately 100 million acres.[12] Although they all carried favorable benefit-cost ratios for flood control, many of the dams also eventually benefited other purposes, such as navigation and hydropower. President Roosevelt signed the bill into law on 22 June 1936.

The agency charged to construct most of these projects was the Army Corps of Engineers. Congress also authorized the Soil Conservation Service to plan small watershed projects for upland areas that would retard runoff and prevent soil erosion. Both agencies suddenly faced a tremendous workload and required comprehensive and accurate hydrologic information to plan adequately sized flood control projects. In particular, they needed historical rainfall and runoff data, which could be analyzed in terms of rainfall intensity over more or less identically sized regions. Much of this data came from the Geological Survey and the Weather Bureau.

Within a month after the signing of the 1936 Flood Control, the Corps of Engineers and the Weather Bureau developed a cooperative arrangement that, modified and enlarged, continues to the present day. The two agencies agreed to study storm potential in various sections of the nation, and a Weather Bureau meteorologist was assigned to the Office of the Chief of Engineers. However, Gail Hathaway, chief of the newly created Reservoir Regulation and Hydrology Section within the Corps, realized in 1937 that far more resources were needed to complete all the storm studies necessary to design the flood control projects. In particular, he was concerned about the correct design of dam spillways, which allowed the excess flows from reservoirs to proceed downstream during floods. Consequently, he convinced his superiors in late 1937 to transfer War Department funds to the River and Flood Division of the Weather Bureau to organize a Hydrometeorological Research Section. At about the same time, the Corps initiated a nationwide study of major flood producing storms. All the Corps regional offices supported the effort. Beginning in 1938, the Office of the Chief of Engineers published regulations detailing the objectives and manner of execution of the storm studies. The instructions covered the development of rainfall curves that would show intensity, quantity, average and maximum precipitation, and other factors.[13]

Hathaway had first developed these procedures during 1935-36, while Chief of the Hydraulic and Hydrologic Design Section of the Missouri River Division of the Corps of Engineers, located in Omaha. According to Hathaway,

> The process is simply one of plotting against time the accumulative rainfall for a station at the successive recording times and of drawing a curve through the plotted points by the aid of notations made by the original observer, a comparison of data for neighboring stations, and estimates of frontal movements and wave-hitting actions during the storm, in order to delineate the principal periods of rainfall.[14]

A particularly devastating flood on the Republican River in Kansas in 1935, which killed over a hundred people, had evidently impressed Hathaway with the importance of developing a conservative approach towards flood estimates and spillway size. It also had shown him the futility of convincing some people to leave their homes despite imminent disaster.[15]

Partly the result of Hathaway's influence, the Corps of Engineers changed its design criteria for spillways. When the Corps of Engineers first conducted its "308" studies, its general rule-of-thumb procedure was to design for a flood that was 2 or 2.5 times greater than the maximum flood *of record*. Thus, for example, available records showed that the maximum flood ever recorded for the Missouri River above Fort Peck Dam, then under construction, was 150,000 cfs. The Corps proceeded to multiply that figure by 2.5 and based its Fort Peck dam design on a maximum probable flow into the reservoir of 380,000 cfs, or, it was calculated, a one in 8,000 year flood. The spillway was to accommodate 255,000 cfs.[16] However, the Corps then proceeded to elevate its dam safety margin even higher. In 1936, the Deputy Chief of Engineers, Brigadier General Max Tyler, personally directed that spillways should be designed so that they can discharge at least fifty percent in excess of the *estimated* maximum flow without impairing dam safety. Tyler's guidance focused on the safety factor required for high earthen dams. In contrast, the Water Resources Committee (the old Water Planning Committee) suggested in 1938 that low dams, thirty feet high or less, have a spillway capacity "equal to the [estimated] maximum peak flood flow or to such peak flood flow as may justifiably be reduced through storage in the reservoir above spillway level." [17]

Rather quickly, the Corps began modifying Tyler's very conservative approach. This no doubt partially resulted from new techniques and greater data available to the agency, such as two important Geological Survey reports published in January, 1936: *Floods in the United States: Magnitude and Frequency* and *Rainfall and Run-Off in the United States*.[18] Both reports were not simply compilations of data but also presented up-to-date analyses of the methodologies involved. *Floods* provided information on floods, flood peaks, and river discharges for all the principal rivers in the country since the data had first been collected (which could mean from the late eighteenth to the early twentieth century). *Rainfall* provided minimum, maximum, ten-year average maximum, ten-year average minimum, and average annual precipitation readings from federal and non-federal precipitation stations throughout the country. The two volumes together covered the major areas of surface water hydrology as it was currently understood and significantly increased the data available to the hydrologic community.

The Corps of Engineers quickly adopted some of the new approaches. To determine runoff, the agency used the infiltration theories developed by Horton and others. Instead of depending only on probability analysis, the agency began to use storm transposition methods to determine the appropriate size flood against which protection was needed. This method began with the Miami Conservancy District, organized in 1915 to plan, construct, and operate a flood control system for Ohio's Miami Valley. The Conservancy District had found rainfall and runoff data so inadequate and inaccurate that it developed an entirely new procedure to estimate storms and floods. In the period 1915-1920, it gathered and corrected historical rainfall and runoff data. Its runoff experiments with various kinds of soils significantly advanced the knowledge of soil saturation and soil moisture,[19] while its series of maps depicting 160 of the greatest storms ever to hit the Eastern United States set a new standard.[20] Miami Conservancy engineers and hydrologists continued to study storms, so that by the mid-1930s, their research encompassed 280 storms, and they had developed a methodology for determining a "standard project storm."

The method took four or five of the worst storms that had hit a particular area or similar areas in terms of size, climate, topography, and other characteristics and combined them into a short sequence of storms over the one subject area. From this storm series, rainfall and runoff could be calculated. The aim was not to reproduce the worst possible storm series but to identify the storm series that reasonably characterizes an extreme storm ("standard project") in an area.[21] This flood could then be used as the basis for developing design criteria for flood control structures in a region. Many federal and state water resource agencies used this approach in the coming years.

Decreasing reliance on pure probability analysis led the Corps of Engineers in 1939 to change Tyler's policy to permit a lower percentage if studies and data justified it. A year or two thereafter, the percentage factor of safety was entirely eliminated.[22] As a Corps publication later put it, "Because of the increased reliability of the estimates now obtainable, the need for arbitrary safety factors has been eliminated."[23] The Corps' policy became, in Hathaway's words, to "provide complete security against overtopping of the dam during the most severe flood or sequence of floods considered reasonably possible."[24]

Meanwhile, debates over probability analysis continued. For instance, in the November 1939 issue of *Civil Engineering*,, well-known engineer William P. Creager, author of an important textbook on dam engineering, criticized the use of probability curves in hydrology to estimate the size of giant floods that could be expected only once in 1,000, 5,000, or 10,000 years. Once ascertained, the flood data would then be used to determine the size of a dam spillway, which released excess floodwater coming into a reservoir. Creager argued that "it has been proved by advanced studies and a greater accumulation of data that the probability-method is entirely inadequate."[25] Another well-known engineer, Thaddeus Merriman, argued in a somewhat similar vein in a letter published in the December issue of *Civil Engineering*. He opined that terms such as "thousand year flood" had become catch-phrases that did nothing to serve the public. Engineers should not be designing for such floods. They occur so infrequently, and under such unusual meteorological conditions that, in the words of Creager, "they follow some law of their own."[26]

Eugene Grant, a respected professor of engineering at Stanford and a pioneer in teaching engineers engineering economics, agreed that using 20 or 40 years of data to estimate a 1,000 year flood made no sense. Using probability theory, he demonstrated that even a hundred years of flood data could lead to misleading conclusions regarding a hundred-year flood. At the same time, engineers needed to know "the respective probabilities of various conditions short of the most unfavorable one."[27] He pointed out that probability has different meanings according to circumstances and the questions asked. The probability that a bridge hand will not contain a card higher than a nine can be determined mathematically and involves proven statistical concepts. It requires comparing the number of possibilities of having no card above a nine (347,373,600) with the number of possible thirteen card bridge hands from a 52-card deck (635,013,560,000). Probability becomes more difficult, though, when one asks whether Chicago will receive at least one 1.75 inch rainfall or more in a sixty-minute period per year. There are far too many ways in which this rain could or could not occur.

Grant did not object to engineers' estimating the frequency of extreme events such as a 1,000- or 5,000-year flood, although he did maintain that most water projects did not have to be designed to control such occurrences. His objection was to the method engineers used. Too much was based on too little data and on extrapolation. He suggested that the better method was to interpolate between known values. If that were not possible, "the results obtained should be viewed with a skepticism that increases with the degree of extrapolation."[28]

But time, money, and history argued against Grant's recommendations. States and communities wanted projects authorized and built and would not tolerate indefinite and expensive delays to find more data. Moreover, the data was not always forthcoming no matter how diligent the research. In short, the thirty or forty years of data that Grant, Creager, Merriman, and others thought clearly inadequate was often the norm. By mid-century, most hydrologists agreed that reliance on such short-term stream records could not produce reliable predictions of maximum flood flows.[29] Further advances depended on new methodologies, theory, and instrumentation.

ENDNOTES

[1] Weston E. Fuller, "Flood Flows," *Transactions of the American Society of Civil Engineers* [Hereinafter *TASCE*] 77 (1914): 564-564-617; ibid., Horton's comments, 663-664. See also, H. K. Barrows, *Floods: Their Hydrology and Control* (New York, 1948), 35.

[2] Allen Hazen, "Storage To Be Provided in Impounding Reservoirs for Municipal Water Supply," *TASCE* 77 (1914): 1539-1640.

[3] Chester O. Wisler and Ernest F. Brater, *Hydrology*, 2nd ed. (New York, 1959), 278; H. Alden Foster, "Duration Curves," *TASCE* 99 (1934), 1234-1235, and the discussions on the paper presented by Richard Pfaeler, Edward Sargent, and Howard L. Cook, 1236-1238 and 1246-1249

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FLOOD STANDARDS IN OTHER COUNTRIES

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The paper discusses flood standards or “floodplain management” in Canada, England, France, Italy, Norway and the European Union in order to stimulate discussion regarding the use of the 1% (100-year) flood standard and how it relates to those used in the United States.

Canada

Under the Canadian constitution, floodplain management essentially falls under the jurisdiction of the provinces, as they are primarily responsible for water resources and land use matters. Major flood events in 1970s were the catalyst for the Federal government to initiate the national Flood Damage Reduction Program (FDRP) in 1975 under the Canada Water Act. It represented a significant change in approach from an ad hoc structural response to flooding to a more comprehensive approach focusing on prevention and non-structural measures. The FDRP, undertaken jointly with the provinces, consists of identifying, mapping and designating flood risk areas, and then applying policies to discourage future flood prone development in those areas. This program is cost shared under federal-provincial agreements, which stipulates the mapping and regulation of floodprone communities. See Attachment A for construction and mapping standards.

England

Development and Flood Risk is the United Kingdom (UK) standard for new building on floodplains. Planning Policy Guidance Note 25 (PPG25). This guidance states that:

- The susceptibility of land to flooding is a planning consideration;
- The Federal Environment Agency has the lead role in providing advice on flood issues, at a strategic level and in relation to planning applications;
- Development plans should give consideration to flood issues in light of uncertainties inherent in the prediction of flooding and the expected increase as a result of climate change;
- Planning authorities should recognize the importance of functional floodplains, where water flows or is held at times of flood, and avoid inappropriate development on undeveloped and unprotected floodplains;
- Developers should fund the construction and maintenance of flood control that are required because of the development;
- Planning policies and decisions should recognize that the consideration of flood risk and its management needs to be applied on a watershed basis and not be restricted to floodplains.

PPG25 requires a sequential test of flood risk and identifies 3 'flood zones'. Any proposed development can be categorized into a flood zone, depending on the site's individual risk of flooding. Local planners are requested to give priority to allocating/permitting sites within the lower flood risk zones. See Attachment A for construction and mapping standards.

France

Water management in France is based on three major principles: ***legislate to decentralize***, ***consider water as a commodity***, and ***establish a "polluter pays" system***. France is divided into six major watersheds. Each watershed has a watershed agency often referred to as a "water parliament" because it brings together all stakeholders: elected officials, consumers, and representatives of federal, regional, and local governments. The watershed agency bills consumers on the basis of water consumption and level of pollution generated. After the violent flooding of 1981 in the Saône and Rhone Valleys as well as in the southwest portion of France, the Parliament passed a law on July 13, 1982 that established this country's natural disaster compensation system. This new law had two main objectives: the expeditious compensation of losses suffered by victims and the prevention/reduction of future damage. Everyone who has auto, home and business insurance that covers damages, such as fire, water damages or loss by theft, is automatically covered for damages to their property caused by flooding, landslide, drought, avalanche, earthquakes, etc. As a counterpart of the indemnification system, the 1982 law encourages the development of local hazard mitigation plans. The objective of these plans is to map risk zones and prescribe measures of prevention. To deal with major natural risks (avalanches, landslides, etc.) that threaten human lives, the 1982 law foresaw a new application of eminent domain to protect public safety. Property owners subject to eminent domain are then indemnified by a fund provided by appropriating 2% of contributions financing the natural disaster system.

Responsibilities are shared by the state and communities, but the local community remains at the centre of flood hazard prevention. According to article 131-3 of the code of municipalities, the federal government may intervene if the local community defaults on its responsibility. The federal government may prepare prevention plans for natural hazards. See Attachment A for construction and mapping standards.

Italy

Law 183 of 1989 (183/89), which governs water resource management in Italy, emphasizes the importance of the complex dynamics and interactions between terrestrial and aquatic environments and designates the watershed as the most appropriate feature for managing the naturalistic and environmental protection of Italian rivers. The 183/89 law assigns to River Authorities specific duties, tasks and activities and corresponding goals to be achieved. River basins are furthermore classified as National River Basins or Inter-regional and Regional River Basins.

While the 183/89 states duties and goals to be accomplished by the river authorities for proper management of the territory, there are no common guidelines and specifications. Every single river authority has its own regulations, standards and guidelines. All the river authorities share the same administrative tool, the Basin Plan as administrative and technical instrument providing guidelines for structural and non-structural actions to be performed on the territory. See Appendix A for flood standards outlined in the basin plans for the 7 main national river authorities.

Norway

Modern floodplain management in Norway was developed after major floods in 1995. A National Flood Action Plan, presenting several measures, such as strengthened flood forecasting, a flood inundation map program and guidelines on land use in flood prone areas was put forward in 1997. The Plan stated*: "The most important effort to reduce flood damage in the future is to improve land use planning in flood prone areas."* The Norwegian Planning & Building Act is the main legislation regulating land use and physical planning in Norway. According to this Act local municipalities have the main responsibility for ensuring that areas in risk of flooding or other naturally occurring perils are not utilized so that an unacceptable risk to human lives or material damage arises. The risk of flood, erosion, mass deposition and ice flows must be evaluated for all development areas. The risk must be acceptable in relation to the planned use of the area. Areas that are especially exposed to danger of flooding, erosion, landslides and ice flows may be held on trust for further regulation as a danger zone.

Norwegian Water Resources and Energy Directorate (NWE) is responsible for river safety at national level and for guidance and control of local plans. The NWE is in the position, as the governmental body responsible for river safety, to object to local plans if they do not meet with national standards. Until 1999, when guidelines for land use in flood exposed areas were issued, the problem had been that no quantification of acceptable levels had been made. The guidelines on land use planning in flood prone areas now define differentiated safety levels along two dimensions: type of flood and type of asset. Together with detailed maps of flood prone areas, this has proved to be an efficient tool in improving safety against floods. See Attachment A for construction and mapping standards.

The flood inundation mapping program was started in 1998 and will continue until 2007. The method includes flood frequency analysis, hydraulic simulation based on surveyed cross section of the river bed, GIS analysis identifying inundated areas based on a digital elevation model with high resolution (5x5m) and vertical accuracy (+/- 30 cm).

Some future challenges have been identified and no definite resolution has been reached as of yet:

- Residual risk: there is always a bigger flood; Regardless of chosen safety level, we have to live with a residual risk. In particular related to levees this is a critical issue. The consequences when levees are overtopped are often dramatic. Will we accept them?
- Climate change: consequences for dimensioning;
- Legal status: work with other agencies towards a stronger legal status;
- Definition of classes: simplify and clarify as much as possible to reduce discussions on appropriate class for certain building types;
- Safety levels: the flood inundation mapping has revealed that the difference in flood level e.g. between a 1% flood and a 0.5% flood is in the order of decimeters. Given the uncertainty in modelling, should the difference between classes in terms of probability be made bigger?

European Union

Flood events in recent years resulting in life losses, huge damages, imply urgent reaction. The EU believes that success can only be reached if an interdisciplinary approach is adopted. For transboundary river basins, actions on international level have to be developed. EU Water Framework Directive (2000/60) stipulates that for each river basin, a basin plan that includes floodplain management issues should be developed. The plan should be based on an integrated approach covering all relevant aspects of water management, physical planning, land use, agriculture, transport and urban development, and nature conservation. In the development of a flood management plan, decision makers at all levels (local, regional, national and international) as well as stakeholders and civil society should be involved. Where applicable, the best practices should be taken into account, in particular on: integrated river basin approach; public awareness, public participation and insurance; research, education and exchange of knowledge; retention of water and non-structural measures; land use, zoning and risk assessment; structural measures and their impact; flood emergency; and prevention of pollution. 2000/60 does not specify specific construction or mapping standards in floodplains, rather it relies on each country's existing regulations and authorities as the framework to establish guidance.

Conclusion

Common theme from comparative analysis is that floodplain management is one aspect of watershed management. To effectively address flooding issues necessitates regulations and policy on a watershed level. The EU as well as other countries have recognized this aspect and require action on a watershed basis. ASFPM's "No Adverse Impact" initiative is leading the United States' floodplain management debate in this direction.

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Attachment A: Comparative Flood and Mapping Standards

<table>
<tr><th>COUNTRY</th><th colspan="3">FLOOD CONSTRUCTION STANDARD</th><th>FLOOD MAPPING STANDARDS</th></tr>
<tr><td rowspan="3">Canada</td><td colspan="3">No building, permitting or financing flood prone development in the designated area.</td><td rowspan="3">100 year with stricter local criteria

• Large scale engineering maps usually at a scale of 1:2000 or 1:5000 are used to accurately delineate the flood risk area
• Maps, with scales ranging from 1:5000 to 1:25000, are used to show the approximate location of the flood risk area</td></tr>
<tr><td colspan="3">No flood disaster assistance for any development built after the area is designated (except for floodproofed development in the flood fringe) will be provided</td></tr>
<tr><td colspan="3">Encourage zoning authorities under their jurisdiction to zone on the basis of flood risk</td></tr>
<tr><td rowspan="4">England</td><td colspan="3">No constraints due to river, tidal or coastal flooding.</td><td>Flood Zone 1 - Little or no risk
Annual probability of flooding: River tidal & coastal < 0.1% (i.e. 1 in 1000 year)</td></tr>
<tr><td colspan="3">Suitable for most development. Flood Risk Assessment appropriate to the scale & nature of the development is required. Warning & evacuation procedures should be considered.</td><td>Flood Zone 2 - Low to medium risk
Annual probability of flooding: River 0.1 - 1.0%, Tidal & coastal 0.1 - 0.5%</td></tr>
<tr><td colspan="3">Appropriate Planning Response - depends on location</td><td>Flood Zone 3 – High risk
Annual probability of flooding with flood control where present: River 1.0% or more, Tidal & Coastal 0.5% or more.</td></tr>
<tr><td colspan="3">Suitable for residential, commercial & industrial development, provided that the appropriate minimum standard of flood control can be maintained for the lifetime of the development. Suitable evacuation procedures are required.
Generally not suitable for residential, commercial & industrial development.
Development should be wholly exceptional & limited to essential transport & utilities infrastructure.</td><td>Flood Zone 3 A - Developed areas

Flood Zone 3B - Undeveloped & sparsely developed areas

Flood Zone 3C - Functional floodplains:</td></tr>
<tr><td rowspan="3">France</td><td colspan="3">Minimal risk</td><td>Three categories of zones had been determined:

Yellow zone</td></tr>
<tr><td colspan="3">Moderate risk - requiring an hazard mitigation plan</td><td>Orange zone</td></tr>
<tr><td colspan="3">High risk - prohibiting all construction</td><td>Red zone</td></tr>
<tr><td rowspan="4">Italy</td><td colspan="3">Minimal risk</td><td rowspan="4">From 1:10,000 to 1:50,000 with flood return intervals from 10 to 500 year</td></tr>
<tr><td colspan="3">Medium risk</td></tr>
<tr><td colspan="3">Elevated risk</td></tr>
<tr><td colspan="3">High risk</td></tr>
<tr><td rowspan="4">Norway</td><td></td><td>Fatality</td><td>Damage</td><td rowspan="4">Flood return intervals from 10 to 500 year with a zone without inundation, but with risk of flooding in basements is also calculated.</td></tr>
<tr><td>Outbuildings</td><td>1/100</td><td>1/50</td></tr>
<tr><td>Domestic buildings</td><td>1/1000</td><td>1/100</td></tr>
<tr><td>Critical facilities</td><td><1/1000</td><td><1/200</td></tr>
</table>

Attachment B: Figures

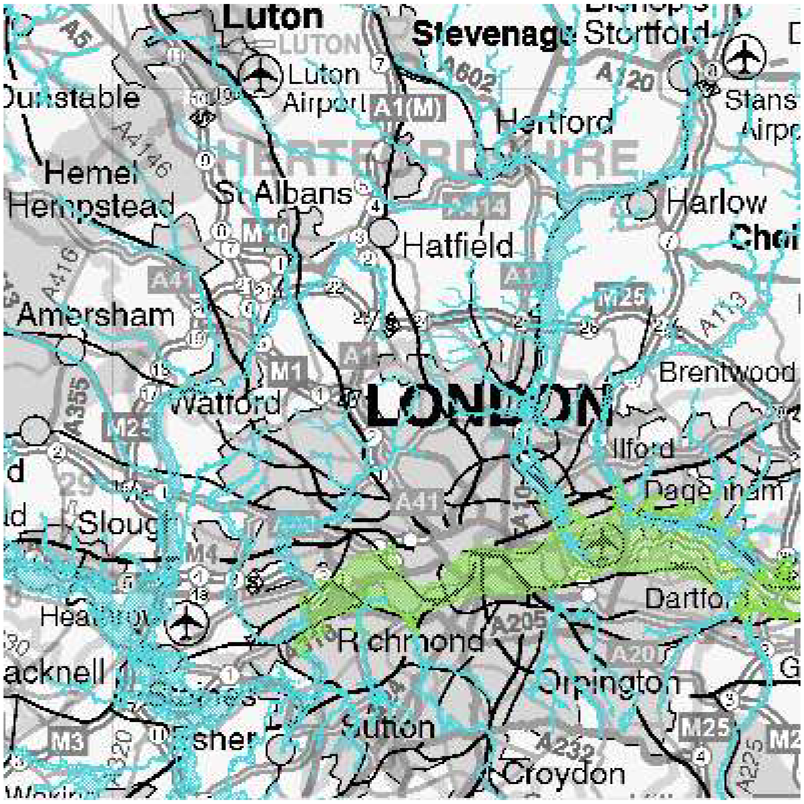
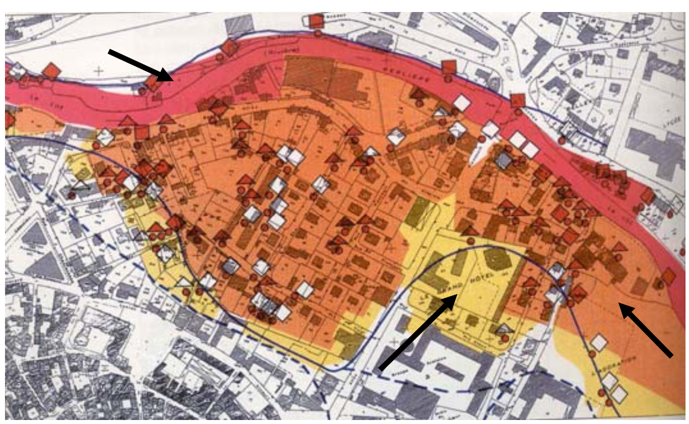


Figure 1: U.K. On-line Floodplain Maps (http://www.environment-agency.gov.uk)

HIGH RISK



MODERATE RISK

LOW RISK

Figure 2: Floodplain map for the Village of Mende in south-central France showing the different risk zones

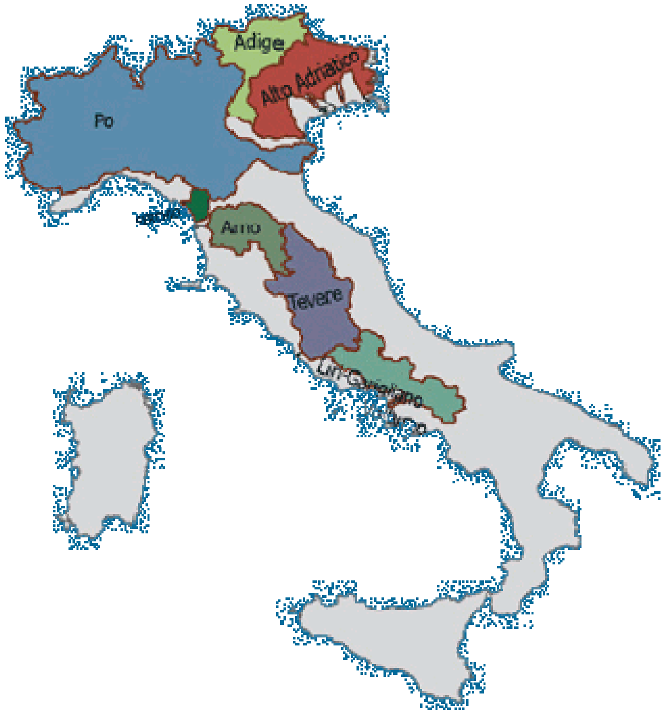


Figure 3: The 7 main national river basins in Italy

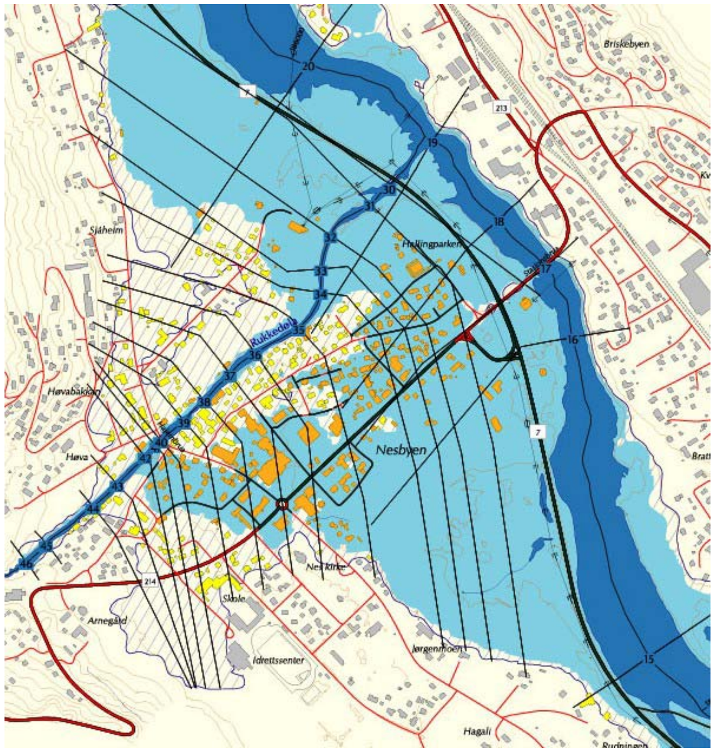


Figure 4: Flood inundation map in Norway

BINATIONAL PERSPECTIVES ON FLOOD RISK

Lisa Bourget and Ted Bailey
International Joint Commission

Canada and the United States differ in their approaches to flood preparedness, mainly due to constitutional differences in responsibilities for resource management. The United States has a framework at the national level for dealing with flood-related issues through the National Flood Insurance Program, mitigation initiatives under the Robert T. Stafford Disaster Relief and Emergency Assistance Act, and a national mitigation strategy. The 100-year or one-percent chance flood is the national standard for flood insurance and floodplain management purposes, with the 500-year or 0.2-percent chance flood used for any critical action using federal funds.

Despite having been recognized through the 1980's and 1990's as a leader in flood management with its federal Flood Damage Reduction Program, the Government of Canada has withdrawn from this activity, leaving the responsibility to provincial and local levels of governments. The federal government does maintain Disaster Recovery Financial Assistance Arrangements under the Office of Critical Infrastructure Protection and Emergency Preparedness to enhance the response and recovery capacity of Canadian communities. This program has generally been reactive in nature.

The Government of Canada is moving forward with the development of a national disaster mitigation strategy by which all levels of government and interested stakeholders can co-operate effectively to evaluate, prioritize and implement risk and impact reduction measures (Public Safety and Emergency Preparedness Canada, 2004). This may provide a much-needed framework within which flood risk and mitigation activities will be focused. The current Canadian approach is less integrated than that of the United States and tends to be event-driven, with no common programs or frameworks tying activities together. Different provinces have different standards for examining flood risk. British Columbia uses the 1:200 flood generally, but in some circumstances, such as on the Fraser River, uses the flood of record. Saskatchewan uses the 1:500 year flood (International Red River Basin Task Force, 2000). Manitoba's minimum standard for flood proofing in the Red River Valley is the level of the 1997 flood plus two feet; required building levels in areas of Manitoba outside the Red River Valley are based on the flood of record in those areas (Manitoba Water Stewardship, ,n.d.).

The International Joint Commission is a binational treaty organization whose mission is to help the U.S. and Canadian governments prevent and resolve transboundary disputes, primarily those associated with water quantity and water quality. In 1997, President Clinton and Prime Minister Chrétien agreed to ask the Commission to study the Red River flood that affected North Dakota, Minnesota, and Manitoba and to recommend means to reduce, mitigate and prevent harm from future flooding in the basin.

The Commission's report to the two governments, *Living With The Red* (International Joint Commission, 2000), emphasized the need for binational cooperation and planning to enhance flood mitigation, preparedness and response. It recommended that governments use, at a minimum, the one-percent flood as a basis for floodplain management regulations and revise their estimates of 100-year flood levels based on new data that become available. However, it also stated that consideration must be given to greater than 100-year flood protection when the expected impacts of such larger floods are unacceptable. It supported the use of the 0.2-percent flood to inform the public of potential risks of flooding from rare events and as the basis of regulations for siting and flood-proofing critical facilities. Further, it recommended that the design flood used as the standard for flood protection works for Winnipeg, the largest community in the basin (population 670,000), should be the highest that can be economically justified or, at minimum, the flood of record, the 1826 flood. The 1826 flood had an estimated recurrence interval of 1 in 300 years at Winnipeg. Winnipeg's flood defenses were stretched to the limit by the 1997 flood, which had an estimated recurrence interval of 1 in 90 years.

Climate change studies suggest different and more variable patterns of precipitation, with increased storm intensity. These effects may significantly change previously-estimated flood recurrence intervals. Vigilance to update such recurrence intervals must become common practice based on actual events or on regional analyses of events likely to occur in the particular area of interest.

The one-percent chance flood is a useful standard that provides for even-handed application among diverse situations. However, it should not obscure historical perspectives that can provide a clear picture of not only what is possible, but what has in fact occurred. Neither should it prevent consideration of increased protection where consequences of failure are unacceptable, or where uncertainty looms large. Examining different approaches to floodplain management can provide perspective concerning the nature of flood risk. The United States and Canada have taken different approaches, but in both instances the trade-off is ultimately in terms of acceptable risk versus affordable protection. For transboundary watersheds, mitigation to address these risks ideally should occur within the context of an integrated approach based on a comprehensive flood mitigation strategy for the entire basin consistent with national frameworks.

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SHORTCOMINGS IN THE 1% CHANCE FLOOD STANDARD

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There is wide acceptance that the concept of a `flood standard' is integral to sound floodplain management policy. Difficulties arise in how to define what the standard should be. `A one size fits all' solution, such as a blanket 1% flood event is neither acceptable scientifically nor does it satisfy economic and social criteria. I will leave others to discuss the detail of where and how it evolved, although there is no doubt that its widespread use within the United States National Flood Insurance Program ensures that it would be difficult to change. American colleagues may not be fully aware that its near-universality does not only apply to the USA. On numerous occasions I have encountered, across three continents, senior planners that state they recommended the 1% standard because their legal experts informed them that the 1% standard was used in the USA and that this provides legitimacy for its wider use. Floodplain management across the world owes much to the pioneering work in this field in the USA but it is to be regretted that the fixation on the 1% standard flood has become an integral part of such endeavours.

I will illustrate where we have been and where we might go from examples of Australian floodplain management. The Australian federal constitution allocated matters of land and water, including those of flooding, to the States. This provides a fascinating mixture especially for academics interested in comparative floodplain management policy. As a generalisation urban floodplain management, especially as it applies to dwellings, has been stolidly founded on the use of the 1% standard. In terms of policy and its implementation, New South Wales has been the leading Australian State over the last thirty years or more. Until the mid-1980s NSW State policy rigidly required local governments to use the 1% standard, a coercive approach universally condemned by councils. This was replaced by the `merits approach' that actively encouraged local councils to select a flood standard relevant to local conditions. Given this freedom and financial aid to assist the associated comprehensive flood studies, the individual councils almost without exception, elected to go with the 1% standard! For those who wish to learn more of the NSW approach the *Floodplain management manual: the management of flood liable land* (NSW Govt., 2001), provides an invaluable guide The pattern is similar for the other Australian States. A comprehensive account of the evolution of the NSW floodplain policy is provided in May et al (1996).

What are the shortcomings of the 1% flood standard?
There are three basic problems:

- major differences in the flood-height range between locations;
- lack of consideration of floods that exceed the standard;
- lack of consideration of over-floodplain flow velocities.

Let us consider two separate urban locations, A with a flood height range between the 1 in 20 and 1 in 100 year floods of say 6m and B with a height range of less than 1.0m. The additional flood heights from the 1 in 100 year to the probable maximum flood are 8m for A and 0.5m for B. When a 1 in 100 yr flood occurs a dwelling based on the 1 in 20 yr flood line at A would have 6m of water over the floor in contrast to B where the depth would be less than 1.0m. For extreme floods, dwelling for town A on the 1 in 100 yr flood line would be inundated over roof level in contrast to those for B which would have less than a metre over floor level.

Without providing detailed loss estimates for the two cases it is clear that for A, relative to B, damages will be high and for extreme floods there would be a major risk to life.

If consideration is also given to the inclusion of over-floodplain flow velocities there is a very real chance that in an extreme flood the dwelling at location A will experience structural failure with dramatically enhanced damages and a greater risk of death.

All too often the unqualified acceptance of a 1% flood standard is set without a hydrological study that provides information on the probable maximum flood, the worst case scenario, or analysis of over-floodplain velocities. A problem enhanced by the practice of colouring on flood maps the land that is below the 1% standard in blue and leaving the land between the 1% standard and the probable maximum flood unshaded.
The outcome is that the 1% is frequently interpreted as the line dividing flood free and flood prone. Thus, the consequences of the inevitable extreme flood are for practical purposes ignored.

There is also the less obvious link that arises because the 1% standard is often also used as the optimum protection level for structural mitigation works.

Risk Management-based Flood Standards

Since the mid-1990s emergency management in Australia has shifted its focus to risk management. This commenced with the publication of the J*oint Australian/New Zealand Standard on Risk Management* (1995), a generic approach for use across the public and private sectors encompassing such diverse topics as financial markets and natural hazards. *Emergency Risk Management – Applications Guide* (2000), extended the concepts to emergency management. This approach has been incorporated into floodplain management and has led to a much greater emphasis on the identification, analysis, assessment and treatment of flood risk. Specifically this includes serious consideration of the probable maximum flood. In the NSW Manual (NSW Govt., 2001) the key step in council floodplain management is now the preparation of a Floodplain Risk Management Study. This includes the selection of the flood standard to be used by the community and requires that information on flooding extends to the probable maximum flood and that the potential for building failure in response to depth and velocity is considered.

This does not in any way simplify the process but it places emphasis on balancing social, economic, environmental and cultural costs of restricting land use and of mitigation measures (especially structural) against the benefits of the reduction in damages, frequency and danger to the community at risk.

Where to next?

Worldwide floodplain management policy is firmly based on the use of the 1% standard flood. Although the 1% standard is better than no standard, it is difficult to defend and falls far short of the optimum. The alternative of providing rigorous guidelines for a community to select a locally appropriate standard is unlikely to provide a workable solution. The pre-1986 experience in New South Wales confirms the view that communities are unwilling to set locally appropriate standards even when opportunity and resources are available.

However, it is imperative that risks to the members of the community from flood events that are life threatening, such as high flood flow velocities and depths, are incorporated into the planning process. The change in emphasis in Australia to include Risk Management Assessment has been widely adopted and provides a more significant role for emergency management agencies in floodplain management decisions.

An unusual feature of residential urban flooding in Australia is the absence of commercial or government insurance cover for flood losses and, in contrast to the USA, flood standards are not involved with matters of insurance. Contrary to economic theory, this does not result in avoidance of flood-prone locations for dwellings However the federal and state governments have for several decades assisted private homeowners who suffer flood losses. This gives those governments some leverage in requiring the adoption of acceptable flood mitigation practices. Currently one of the major thrusts of this influence is concerned with the adoption of risk management strategies.

This is not to suggest that the current Australian situation provides an exemplar that could be used elsewhere. Major changes to the 1% standard are, in my opinion, unlikely to occur. If this assertion is accepted, it is essential that enforceable policy to mitigate serious risk to life be adopted. Analysis based on the principles of emergency risk management offers an approach to achieve this aim.

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LIVING WITH THE 1% FLOOD STANDARD - HELP OR HINDRANCE?

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Many in the floodplain management business seem to believe that losses associated with development in floodplain locations are so dominant as to outweigh the benefits. But this question needs to be candidly addressed before policy advocacy begins. Thus, if this forum is open to the pros and cons of policy change, along with the consideration of a range of evidences, its recommendations are more likely to be seen as sound. We are here to debate the adequacy of the 1% standard. In that debate, we must recognize that managing floodplains is really about communities managing their residual risk - both physical and financial. We need to strike a balance between uses of floodplains and the risk associated with those uses. We do not want this forum to be seen as one-sided, with human occupation being unnatural and associated only with losses and "casualties," and floodplain "de-occupation" associated only with nature and its "beneficial functions."

The history of human occupation of the earth suggests that domination of costs and losses over benefits is at least in question. Indeed, in some areas it appears that the flooding river - and importantly and perhaps essentially, flooding in combination with engineering works - was a major enabler of civilization. Further, in modern times, as in ancient times, the floodplain location advantage consists of a matrix of uses and not just single points (losses), as is evident in the behavior of individuals and communities. Individuals, and later communities, found that the floodplains' flat ground, easy access to water and food, and easy transportation were valuable locations.

The advantages of living and working near the water today are the same as in the past but if we do not feel secure and we want to further prevent or reduce flood losses, how should that be accomplished? We have tried to keep the flood waters away from us but now we are placing more emphasis on keeping us away from the threat of flooding. One measure we have developed and used to help evaluate our use of the floodplain is the 1% standard. But is this a good measure?

Let me briefly review the history of how the 1% standard was originally adopted as described in the September 1983 report entitled *The 100-Year Base Flood Standard and the Floodplain Management Executive Order: A Review Prepared for the Office of Management and Budget by the Federal Emergency Management Agency*.

Once the Federal government embarked upon programs in the early 1900s to control flood losses by both structural and nonstructural means, different agencies adopted different standards to implement their programs. In designing and constructing engineering structural works, the Corps used the "standard project flood" as its design standard while TVA adopted a design standard using the "maximum probable flood" as a reference. When TVA began its nonstructural community flood damage prevention program in 1953, it adopted a "regional flood" standard estimated as a 50-year, or more, magnitude/frequency level. Under the Flood

Control Act of 1960, the Corps began its nonstructural flood hazard mitigation assistance to State and local entities using an "Intermediate" base flood level estimated as a 100-year flood magnitude/frequency level while the Soil Conservation Service was using an estimated 25-year magnitude/frequency level as a standard in agricultural flood hazard areas and 100-year level in urbanized areas.

By the early 1960s, both the Corps and the TVA were engaged in nonstructural, floodplain management studies and agreed on a standard that would identify a major flood without being unduly restrictive – a flood level representing an intermediate magnitude/frequency that would be derived on a regional basis to reflect local and regional needs. The 100-year flood level was selected because a flood of that magnitude and frequency represented a reasonable probability of occurrence and losses worth protecting against as well as an immediate level that would alert planners and property owners to the effects of even greater flood levels.

The National Flood Insurance Program was authorized in 1968, and administered by HUD. The NFIP adopted the 1% annual chance flood as a minimum national standard for floodplain management, based on a recommendation of a special review committee of national experts that met at the University of Chicago in December 1968. The rationale was that "the hydrologic method uses the techniques of analysis developed and widely used by hydrologists and hydraulic engineers for many years to determine the economic feasibility of flood protection and flood abatement projects out of which the use of the benefit-cost approach have come standard techniques for integrating flood frequencies with damages to properties from flooding". This decision was later codified in the Flood Disaster Protection Act of 1973, where after considering the statements of all interested parties, the Senate Committee on Banking, Housing and Urban Affairs concluded that the 100-year standard was reasonable and consistent with national objectives in reducing flood losses. Further, in 1976, the Water Resources Council recommended that the President formalize the relationship of E.O. 11988 to the 100-year base flood standard in order to be consistent with the standard utilized by the National Flood Insurance Program and communities across the Nation.

Much has changed since E.O. 11988 was signed. Local management, local achievement, and importantly, local objectives should not be downplayed. In this day and age it would be difficult to find local authorities that are not aware of the potential impacts of floodplain use. This forum must consider this aspect and should not assume that local objectives are in error because they may differ from the objectives of national policy.

For Corps of Engineers project planning purposes, the 1% flood standard is an effective tool for communicating flood information and the associated risk to the public. Prior to the standard, reference floods were usually local historical events and that did not facilitate between-community communication. Following the development of the standard, the general public better understood the magnitudes and frequencies of flooding. A better-educated public makes Corps of Engineers planning efforts easier. Increasing the local sponsors' understanding of existing flood risks and heightening their awareness of residual risk, increases the likelihood of acceptance of more balanced projects that address both economic and environmental needs. Maps depicting the 1% flood and regulatory floodways are useful tools for communities, effectively showing where development should be avoided. As a result, public attitude towards the value of open floodplain space is changing.

However, there are potential negative impacts on Corps plan formulation efforts using the 1% standard. In some cases, the local sponsors want 1% flood protection in order to eliminate flood insurance purchase requirements and restrictions on future development to relieve financial burdens and create opportunities for productive investments and job growth. The sponsor may argue that it is unnecessary to develop numerous flood damage reduction alternatives just to arrive at the 1% solution thus limiting the investigation of potentially better alternatives for floodplain use.

The 1% flood standard infers little residual risk/impact on communities; however, the significance of residual risk is often overlooked. Tools that could be used, but normally aren't, include: flood insurance purchase requirements in areas of "significant" residual risk (e.g. behind levees). The 1% flood is a viable standard but communities must be made aware of the potential for floods greater than the 1% flood. Tools exist to identify and categorize residual risk; however, there is a need for better comprehension of the impacts of residual risk on communities. Have we adequately assessed those risks? Are our hydrologic analyses adequate? Is our mapping accurate and current? Is our communication of the residual risk clear and unambiguous? Have we adequately described the economic and environmental uses of the floodplain so that the trade-offs can be properly framed?

In summary, the 1% flood criterion is a compromise, arrived at through a democratic process, which achieves multiple ends, one of which is containing the growth in floodplain losses. To expect and to argue, for example, that floodplain losses should be reduced absolutely when compared to some historical benchmark could be to deny to those fashioning the criterion the validity of their own experience and insight, and that of their constituents. That is, experience and observation confirm that a growing economy and a growing population will be subject to some level of losses, absent a draconian rule that jeopardizes growth itself. More plainly, adjusting a rule perceived as not achieving its assumed single purpose objective is one thing, while advocating overturning a democratic compromise is quite another.

Therefore, let me conclude by asking: In living with the 1% standard, is it a help or a hindrance?

OBJECTIVE GUIDANCE OF FLOODPLAIN USE

L. Douglas James
National Science Foundation

For more than 40 years, I have been interacting with Gilbert White on issues related to flood control engineering and floodplain management; and he fully deserves this recognition as the leader in moving society toward innovative ways for dealing with flood problems. He has told us all that the really important issues in land and water management should be based on thoughtful analysis of the alternatives made possible by sound science and the latest engineering technology.

The point that I want to make here is that the general application of the 1% flood is not the product of such thoughtful analysis and does not take advantage of either sound science or current technology. It is an arbitrary uniform national standard that was taken from the correspondence of a Texas Congressman and adopted to guide floodplain management with the inauguration of the FEMA program in the 1960s. When the program was in its infancy, a uniform standard was taken as a practical approach to use in a national program. It was a balance between being reasonably fair and equitable for the nation and the many uncertainties in defining flood risk and estimating potential losses.

Even then, everyone knew that 1% floods at different locations vary greatly in their consequences for the occupants of floodplains. In some areas, 1% floods are shallow and of short duration and only a temporary nuisance for people reaping substantial benefits from their floodplain occupancy. It is neither fair nor equitable to forbid or severely inhibit floodplain uses that provide substantial economic and societal benefits when the users would experiences only minor experiences only two or three times in a lifetime.

On the other hand, there are other lands that are outside the 100-year floodplain where a 200-year flood would cause massive property destruction and substantial loss of life. There, it makes no sense to give occupants of these areas a sense of financial security and safety because they are abiding by a regulatory standard.

In short, a uniform 1% standard is depriving some people of substantial benefits and exposing others to life-threatening risks. It neglects the differences in ecological attributes that give some floodplains great environmental value and leave others as wastelands or environmental threats. Objectivity demands that we turn from any such arbitrary standard and instead use fundamental principles from economic analysis, environmental quality, and social well-being in selecting a suitable standard.

The national flood program has achieved a great deal. The loss of life during flood events in the United States has been greatly reduced. We experience far less damage from floods in the 10- to 100-year range. Residential development is shifting to locations outside of floodplains.

Despite this progress, average annual economic losses are still increasing. We experience floods larger than those designated as 1% events more often than expected because of errors in hydrologic or hydraulic analysis, because flood peaks have been increased by upstream development, because small watersheds not recognized by the program generate damaging floods, etc. When it goes to estimating damages, we find that people are more exacting on repairs and find that they must pay more for quality work. More of the damages are occurring in areas where people are not experienced in dealing with flooding and during rare events where people cannot draw on past experiences in deciding what to do.

These issues point out that the 1% flood at any location is a moving target. Its magnitude changes with climate, tributary land use, upstream channelization, altered detention or retention storage, levee conditions, etc. However, once it has been used to determine a peak flow or a peak stage as a basis for regulation, the numbers are not easily changed. The result is that information on the 1% flood available to floodplain occupants is based on conditions at some prior time when a study was made and, for reasons given above, likely to underestimate risks.

Fortunately, the 40 years since the 1% flood became the standard have seen great advances in information technology. We are arriving at a time when we can specify a location and use available software to determine the frequencies, depths, and velocities of the floods to which it is exposed. We can use principles from land economics to develop software to estimate the income that an owner of that property could gain from a specified development. We can factor the costs of protective flood proofing into that calculation. We can apply considerable research to develop software to determine environmental impacts. Other software can provide assessments of societal impacts and threats to human life. We can calculate the impacts of development at a site on other land uses nearby. In short, we are close to having packaged programs that can take a property description and provide all the above results in minutes.

In addition, we can use information technology to advise property owners on ways to flood proof existing property or new construction and prepare for potential flood events. We can provide communities guidance on building codes. We can offer advice in real time that both individuals and officials can use to respond to rising flood stages (whether by flood fighting or by evacuation), finding safety during events, and on cleanup and repair afterwards.

As the information and warnings are made available to local governments and to property owners, communities can use the information to plan protection programs and prepare for flood emergencies. Occupants better informed on the consequences of taking risks can do better jobs of flood proofing. State and Federal officials will have guidance to use in managing relief programs that fit current conditions. Zoning boards and urban planners will have information that will help them plan for the future.

In working toward this ideal, we cannot be blind to potential problems and practical limits. Some developers will take parts of the information to gain advantage. Regulators do need to use zones of "equal" hazard because the regulatory system becomes overwhelmed when faced with large numbers of fine distinctions. While problems and limitations are not an excuse to do nothing, we must temper our idealism with reality.
The best course is to continue to refine and improve the program while recognizing that institutional change comes slowly.

The really important lesson that Gilbert is trying to teach us is to work toward a vision. We need a goal – every floodplain occupant provided the information needed to secure safety and prevent life-disrupting surprises and every parcel of flood plain land used in the best interest of society. We can progress toward that goal by taking greater advantage of information technology.

Gilbert started a good thing, a very good thing. Now, we owe it to society not to stagnate by letting our early baby step of fixing on a 1% flood to solidify in concrete. The national flood program must be managed in recognition that we live in a dynamic society in a changing world, and this means making adjustments that meet the needs of the times. Gilbert White's contribution was to started us down the road of using the technologies of the day to protect public safety and to support wise use of floodplain land through time.

EVALUATION OF THE NATIONAL FLOOD INSURANCE PROGRAM

Rich Tobin
American Institutes for Research

Flooding is the most costly natural hazard in the United States in terms of deaths, damages to infrastructure, property, and destruction of crops and wildlife. Between 1955 and 1999 floods in the United States were estimated to have caused an average of about $6 billion in damages per year. Congress established the NFIP with the passage of the National Flood Insurance Act of 1968 (PL 90-448). The NFIP's goals are to decrease the risk of flood losses, reduce the costs and adverse consequences of flooding, reduce the demands and expectations for disaster assistance after floods, and restore and preserve the natural and beneficial value of floodplains. The program has nearly 20,000 participating communities with 4.43 million policies and $666 billion of insurance in force.

FEMA awarded the American Institutes for Research (AIR) a multiyear contract in 2001 to evaluate the NFIP, the first comprehensive evaluation in the program's 36-year history. Given the program's size, scope, and national importance, an in-depth evaluation of its impact on flood risk and costs is imperative. The evaluation is assessing the effectiveness and efficiency of the NFIP and identifing promising alternatives and practical recommendations, using research questions identified by a committee of FEMA staff, retired government executives, and private sector and academic experts. A Steering Committee, composed of 15 natural hazards experts, environmental and insurance industry practitioners, mapping, floodplain management, and engineering professionals, current and former FEMA officials, and local community officials has provided recommendations and refined evaluation products most beneficial to FEMA's needs. AIR and its subcontractors have initiated work on 12 studies, examining a myriad of components of the NFIP. While the substudies address discrete research questions, substantial coordination and information sharing among subcontractors has aided in the refinement of products.

The substudy entitled *1 Percent Chance Flood Standard* began in September 2004 and examines the implications of the accepted floodplain standard and the basis for floodplain mapping, management, and insurance for the success of the NFIP. The substudy addresses the following three research questions:

1. What are the implications of making the 1 percent annual chance flood standard a threshold for mandatory insurance purchase and flood management ordinances? Is the standard adequate in reducing risks from flood losses?
2. What probability levels capture 50 percent, 75 percent, and 90 percent of disaster costs in a sample of coastal and riverine floodplains? If the standard is changed, how will it affect flood losses avoided, property values, NFIP loss experience, Map Modernization efforts, map revision and amendment costs, costs to states and communities in revising regulations and ordinances, insurance sales and rates, and federal flood disaster expenses in areas that face flood hazards below the 1 percent annual probability threshold? The

analysis assumes that rates will be grandfathered for existing structures in areas outside the 1 percent flood hazard boundaries as well as those properties that have been grandfathered administratively.
3. If the 1 percent annual chance standard is deemed to be the most suitable standard, are there ways that its use or the restrictions associated with its use can be improved?

Three possible approaches to assessing total and marginal disaster costs have been suggested:
1. Compare damages and disaster costs from communities that regulate to a higher standard than the 1 percent annual chance standard, such as requiring freeboard;
2. Examine damage reduction by regulating to a higher standard; or
3. Use the HAZUS flood damage simulation model to simulate the change in damages under selected conditions, e.g., with one foot of freeboard above the base flood elevation in the 1 percent annual chance flood.

The study will also take into account the variability of the flood hazard, including trends of BFEs increasing over time. In studies of streams, BFEs have increased over a 20-year period, either due to more development, improvements in mapping technology, or restudies of flood hazards. Similarly, the level of protection offered by a flood standard is likely to deteriorate over time due to floodway encroachments, urbanization of watersheds, climate change and sea level rise, or other factors. FEMA has a variety of regulatory actions available, including setbacks to account for coastal erosion and promotion of storm water management, to balance sufficient flood hazard protection with reasonable insurance rates.

The NFIP Evaluation includes 11 other substudies currently underway: *Mapping Anticipated Development*, conducted by ABS Consulting, assesses the costs and advantages of reflecting anticipated development in flood maps using case studies in Pensacola, Fl: Grand Forks, ND; Houston, TX; Fort Collins, CO; Mecklenburg County, NC; and DuPage County, IL.

Risk Perceptions, conducted by AIR, uses focus groups and interviews with insurance agents to assess the factors that affect the decision to purchase a flood insurance policy. Factors examined by the study include cost, peace of mind, experience with flooding, and perception of flood risk.

Market Penetration, conducted by RAND Corporation, develops more precise estimates of NFIP market penetration and compliance with the mandatory purchase requirements. The substudy will also examine the potential market for flood insurance and the determinants of market penetration with implications for policy growth rate targets.

Deloitte and Touche examines one of the long-standing debates regarding the NFIP – whether actuarial soundness is an achievable or appropriate goal for the NFIP. *Actuarial Soundness of the NFIP* defines actuarial soundness, its indicators and obstacles, and assesses FEMA's progress to its goals.

AIR conducts a study entitled *The Mandatory Purchase Requirement*, which explains the players and processes involved in complying with the requirements for the mandatory purchase of flood insurance.

Minimal Building Standards, conducted by Christopher Jones & Assoc., identifies the building standards that have the greatest impact on reducing flood losses and examines whether existing building standards are sufficient to protect buildings from damage caused by the 1 percent annual chance flood. The *1 Percent Annual Chance Flood Standard* study will serve as a complement to this study by taking into account factors other that building damage – such as protection of critical public facilities and reasonable insurance rates – in recommending a change in NFIP standards.

Part A of *Evaluating Community Compliance and of Structures in SFHAs*, conducted by AIR, examines the effectiveness and efficiency of processes for assuring that participating communities enforce building ordinances compliant with NFIP regulations. Part B of the substudy, conducted by Dewberry & Davis, uses local building records and elevation surveys to determine if structures in SFHAs are being built in compliance with NFIP's requirements.

AIR conducts the substudy *State Floodplain Activities*, which focuses on whether the NFIP maximizes the role of state coordinating agencies through legislation, executive orders, and funding programs such as CAP-SSSE. The study also examines the compliance and regulation of construction by other state agencies with NFIP standards and their support of NFIP objectives.

Costs and Consequences of Flooding, conducted by the Pacific Institute for Research and Evaluation (PIRE), examines the impacts that the NFIP has had on the total costs of flooding, the distribution of these costs, and how well the program serves low-income households and communities. Few national studies of the costs of flooding exist. The effects of the NFIP on low-income populations has only recently been identified as an area of concern, and preliminary evidence suggests that Group Flood Insurance Policies have not been as effective as expected. The *1 Percent Annual Chance Flood Standard* study will build on this data, keeping in mind that many disaster costs are not insurable and changing the NFIP standard for insurance and regulation may have little or no impact on many costs.

Crosscutting Measures for Assessment, also conducted by PIRE, evaluates the performance assessment and evaluation measures used by the NFIP and recommends alternatives, if appropriate. The study examines measures FEMA uses to assess the occupancy and use of floodplains, the costs and consequences of flooding, insurance rating and indemnity functions, floodplain management and enforcement, hazard identification and risk assessment, and communications and marketing.

Environmental and Developmental Impacts of the NFIP, conducted by Dr. Tony Rosenbaum of the University of Florida, examines the extent to which the program may encourage or accelerate the development of floodplains and the environmental consequences of such development. The substudy assesses whether the NFIP minimizes damage caused by flood losses and guides the development of proposed future construction, where practicable, away from locations that are threatened by flood hazards.

Initial findings of the NFIP Evaluation have been presented to external stakeholders at ASFPM conferences, the National Flood Conferences in San Francisco and Seattle, the annual meeting of the National Flood Determination Association in Scottsdale, and the Hazards Research and Application Workshop in Boulder, CO. The NFIP Evaluation is projected to be completed in September 2005 and will be made available through FEMA to interested parties.

Part 2

Tools and Technology as applied to the 1% Chance Flood Standard

DIGITAL ELEVATION TECHNOLOGIES — NEW PARADIGMS FOR FLOOD RISK ASSESSMENTS

David F. Maune
Dewberry & Davis

The 1% chance (100 year) *base flood* standard was conceived partly as a result of technology available at the time. Then as now, "100" was a nice round number, and we couldn't imagine the luxury of mapping numerous flood frequencies, each with different water surface elevations (WSELs). Then, hydrologic and hydraulic (H&H) analyses were performed slowly and manually with USGS quad maps that often had 10 foot contours (or poorer). Many H&H parameters were estimated and special flood hazard area (SFHA) boundaries were smoothed, forcing terrain that is naturally undulating to be mapped on DFIRMs as though the floodplain had a cross section like that of a bathtub, with small islands of higher terrain removed within the SFHA. Today, SFHA boundary lines, although estimated or "fuzzy," are authoritative *lines in the sand* that establish *horizontal criteria* as to who needs flood insurance and who doesn't.

Elevation surveys have demonstrated that a high percentage of pre-FIRM structures within the SFHA (≈50% in some communities) are actually above the BFE. Experience has also shown that a high percentage of flood claims (≈30%) are paid on preferred risk policies outside the SFHA. It's time for us to question whether modern elevation technologies can better predict flood probabilities. Along with other needed improvements in H&H modeling, can high precision digital elevation models (DEMs) and new elevation technologies provide cost-effective tools for automated H&H modeling and risk assessment at many levels beyond what we currently define as the *base flood*? Do we even need a single standard?

Today, automated or semi-automated H&H is the norm. Using high-resolution, high-accuracy DEMs, automation enables us to model future conditions and/or update flood studies as conditions change. Airborne Lidar is routinely meeting FEMA's 2 foot contour interval standard, and precision DEMs equivalent to 1 foot contours are now becoming more commonplace. Countywide Lidar and automated H&H (for limited detail studies) are inexpensive enough that they could be used to map small drainage areas (less than 1 sq mi); this might catch local flooding that affects some of the 30% flooded outside the SFHA. Here are three other ideas for consideration, each exploiting the benefits of modern Lidar technology:

1. New York State Floodplain Management Maps, now being produced with Lidar DEMs, show zones AE and A for the base flood and zone X for the 500 year flood — but they use different color lines to depict flood depths of 1', 2', 4', 6', 8', 10', 12', etc. within AE zones. They show small islands of higher terrain within AE zones as being inundated to a lesser depth, or mapped in a totally different zone, even though surrounded by the SFHA. This better depicts variable flood risks within AE zones.

2. Future digital flood insurance rate maps (DFIRMs) could map isolines for multiple flood frequency intervals (today's standard 10, 50, 100, 500 year flood events, or any other frequency such as 10-year frequency bands) depicted as different colored lines while also retaining the islands of reduced flood risk as done in New York. This would enable DFIRM users to interpolate between isolines to estimate the frequency for which flooding is predicted, without just depicting "in or out" for the 1% chance flood event.

3. A third alternative is to rely exclusively on vertical criteria and stop mapping any horizontal *lines in the sand*. Instead, use precise 3-D surface models of the terrain, and apply inundation models to determine the WSEL and flood frequency level when a structure's "footprint" is first touched by flood waters. Flood Zone Determination (FZD) companies, instead of making "in or out" determinations, might instead be in the business of applying flood inundation models to determine the frequency level for which flood waters would reach the lowest adjacent grade (LAG) of an addressed structure.

Already, Lidar-generated 3-D bare-earth surface models are being "intersected" with building footprint files (linked to street addresses in a community GIS) to automatically generate accurate LAGs and HAGS (lowest and highest adjacent grades) for structures within floodplains. Such LAGs are usable for determination of mandatory purchase requirements for flood insurance or to justify mass generation of Letters of Map Amendment (LOMAs). Rather than paying hundreds of dollars each to acquire an Elevation Certificate (EC) for each structure, communities can mass-produce EC-type data by making simple on-site vertical offset measurements between the LAG and the lowest floor elevation for all structures in or near floodplains. A test area in Beaufort County, SC demonstrated that lowest floor elevations derived in this manner (from Lidar tested at 1 foot contour interval equivalency) could produce EC-type data nearly as accurate as that from surveyed ECs, at far lower costs.

The objective is to populate a web-based National Elevation Registry of all structures in or near floodplains, to include LAG/HAG, lowest floor and other elevations (garage floor, air conditioner pads, and lowest horizontal structural member in V-zones). When we know the geographic coordinates of street addresses, computer models can then identify, on a structure-by-structure basis, the flood risk for individual structures and indicate that 123 Main Street in Floodville, for example, is expected to be flooded by a 68 year flood — or a 110 year flood — not worrying about whether the 100 year event is the correct one to map. This changes the debate from "Is the 1% chance flood standard sufficient?" to "Should we even map a single flood standard?"

A Revolutionary Proposal

Assume for a moment that FEMA had the National Elevation Registry described above, but including all structures and not just those in or near to floodplains. Next assume that owners of homes and other structures are routinely required to purchase flood insurance, much like they routinely purchase fire insurance. Whereas fire insurance premiums vary as a function of smoke detectors, proximity to fire hydrants, fire retardant construction materials, etc., flood insurance premiums would vary as a function of lowest floor elevations compared with WSELs for standard flood events (10-year, 50-year, 100-year, 500-year) and perhaps even the 10,000-year flood (as used in the Netherlands). The lowest floor elevation of any structure would fall somewhere within the continuum of predicted WSELs for that structure for which actuarially-based premiums could be determined. Structures located on mountain tops might qualify for flood insurance with an annual premium of $1, whereas structures with lowest floor elevations below any of the standard flood events would pay flood insurance premiums similar to those currently used, based on elevations above or below the BFE. But there would be no one flood standard for insurance premiums; there would only be comparisons of lowest floor elevations with WSELs with predicted frequencies used for actuarial ratings.

There are several major benefits to this approach:

- Flood insurance would be appropriately based on vertical criteria rather than horizontal criteria (that *line in the sand* that we call the SFHA boundary). Since flood risk is a function of elevation data, attempts to depict flood risks on planimetric maps cause needless confusion -- often requiring a FZD company to look at horizontal criteria to determine whether or not flood insurance is mandatory.
- There would be no need for any map to show who needs flood insurance and who doesn't; but there would be a continued need for Flood Insurance Studies to compute WSELs. These studies would utilize automated H&H techniques so that they can be updated more frequently as conditions change.
- Instead of FZD companies making *in/out* determinations, they would instead be making *elevation risk* determinations.
- Since insurance premiums would be based on lowest floor elevations relative to WSELs expected to increase as conditions change, there would be inherent financial incentives for everyone to elevate new construction.
- In all cases, either now or in the future, premiums would be lower when structures are constructed to higher elevations. This is the incentive we need to get owners and builders to recognize the need, even before the start of new construction.
- Everyone would need to purchase flood insurance, so no one would be misled into a false sense of security. There would be no one on the safe side of that *line in the sand*, because there would no longer be a need for any such line to be depicted.

Regulation of new construction would be based on elevations, rather than horizontal location of structures, except for floodways where no construction would be allowed at any elevation.

ROLE OF MAPPING IN SETTING FLOOD STANDARDS

Dean Djokic
ESRI

Uncertainty in hydrologic and hydraulic (H&H) analyses comes from many sources. Assuming that the models correctly capture the physics of the process that they describe, the key aspects in the modeling uncertainty are related to availability of actual observed flood events used in calibration of the models (specially for high frequency events) and the quality of source base data used in H&H analyses.

Maps of various entities are used in all aspects of H&H modeling. Terrain models are used for watershed delineation and cross-section definition, land use and soil types are used for rainfall loss and friction evaluation, and so on. Geographic information systems (GIS) allow relatively easy manipulation of spatial data that are used in developing H&H models and are extensively used for mapping of intermediate and final results. Often, the data used in GIS pre and post processing of H&H models are of different scale, quality, age, and so forth. The variability of these data can have a significant impact on the quality of the final results. Collection of quality data needed to support quality H&H analyses and floodplain determination is an expensive exercise. Setting appropriate accuracies for base data needed for the overall process of floodplain mapping can have significant impact on the timing, cost, and effectiveness of the end product.

Final mapping of a floodplain as a result of H&H modeling process poses special requirements and considerations, especially when such maps have legal, financial, and logistic repercussions. Quality of base data used in mapping (are they the same as the data that were used in H&H analyses), methodology for interpolation of H&H results on the base map, and methodology for identification of the point of interest (where is the property for which we are doing the determination) all have an impact on the final result. The strength of a chain is measured by the strength of its weakest link. While such simple linear interpretation cannot be made for the quality of the H&H model results based on the quality of the input data, it is a reminder that we need to look at all aspects of the floodplain determination process and identify where the weak links are. How do uncertainties in the mapping process correlate to the uncertainties in the H&H modeling process, and how do they impact the overall effort in reducing the flood losses?

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WILL THE DATA SUPPORT MODELING FOR A NEW STANDARD?

Wilbert O. Thomas, Jr.
Michael Baker, Jr., Inc.

Introduction

In August 1982, the Office of Management and Budget directed FEMA to review the use of the base or 100-year flood standard in the NFIP. The findings of this evaluation was that the 100-year base flood standard is strongly supported and being applied successfully. Furthermore, no alternatives have been identified that are superior to it, and there is no evidence to justify the expenditure of funds that would be necessary to convert to another standard (FEMA, 1983).

However, flood losses have continued to increase. Now more than 20 years later, the Association of State Floodplain Managers (ASFPM) Foundation is promoting a new evaluation of the 1-percent annual chance (base) flood standard. The objective of this paper is to examine the data available for hydrologic methods and modeling and recommend whether the available data will support a new more restrictive standard.

Data Considerations

The three hydrologic methods used most frequently in the NFIP to estimate the base flood discharge are gaging station data, regional regression equations and rainfall-runoff models. The use of gaging station data provides the most accurate base flood estimates and will be used to characterize the uncertainty in base flood estimates and elevations. The U.S. Geological Survey (USGS) has collected peak flow data for 10 or more years at about 18,000 locations throughout the Nation. The average record length of the peak flow data for the 18,000 stations is about 25 years.

The uncertainty or standard error of flood discharges at gaging stations is related to the record length, the standard deviation and skew of the annual peak flows as shown in the following equation:

$$SE_x = (S/N^{0.5}) * R_x \qquad (1)$$

where SE_x is the standard error in log units of the x-percent chance flood discharge, S is the standard deviation of the annual peak flows in log units, N is the years of record and R_x is a factor that is a function of skew and the x-percent chance of exceedance.

The standard deviation (S) of annual peak flows in the more humid areas of the Nation is about 0.26 log units while in the semiarid west the value can be as high as 0.78 log units or even higher. Assuming the logarithms of the annual peak flows are Pearson Type III distributed, as assumed in Bulletin 17B (Interagency Advisory Committee on Water Data (1982)), the standard error of the base flood discharge can be estimated by Equation 1. As shown in Figure 1, the standard error of base flood discharge ranges from about 23 percent in the more humid areas to about 75 percent in the semiarid areas even when 50 years of peak flow data are available. These computations are based on the assumption that the standard deviation (S) is 0.26 log units in the east and 0.78 log units in the west or semiarid areas and that the skew is zero (approximate nationwide average).

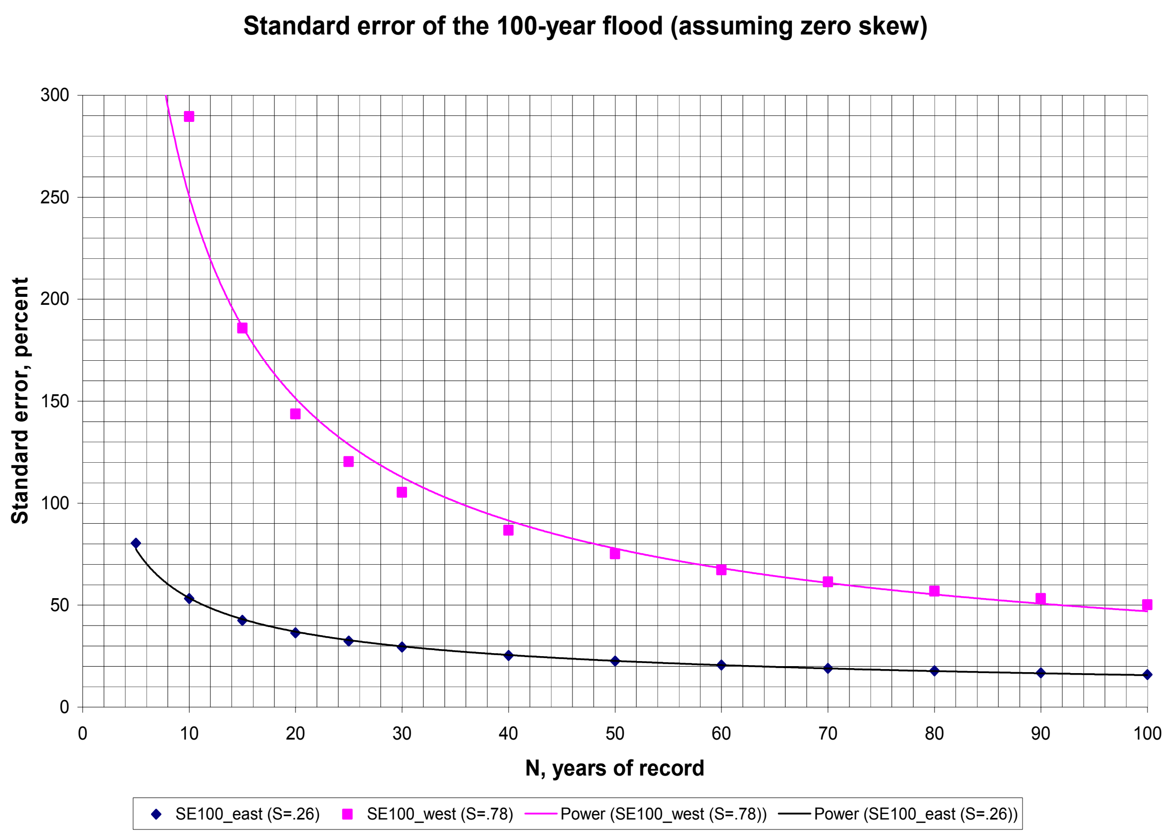

Figure 1. Standard error of the base flood discharge for annual peak flows whose logarithms are distributed as a Pearson Type III distribution with zero skew.

Of interest is the elevation of the base flood or the base flood elevation (BFE). The relation between depth in the channel and the discharge can be expressed by the power equation:

$$d = c\,(Q)^b \qquad (2)$$

where d is the depth in feet, Q is the discharge in cubic feet per second and c and b are constants. Burkham (1978) used stage-discharge relations for 539 gaging stations in seven states (Iowa, Maryland, Minnesota, New York, North Carolina, Ohio and Wisconsin) to define an average value of 0.42 for the exponent b in Equation 2 for discharges greater than bankfull. An exponent of 0.4 is used in Equation 2 to evaluate a change in depth given a change in discharge.

By converting Equation 2 to linear logarithmic form and evaluating the differences in depths for two discharges, one gets Equation 3:

$$\log d_1 - \log d_2 = 0.4\,(\log Q_1 - \log Q_2) \qquad (3)$$

where d_i and Q_i represent flood depths and corresponding discharges. Equation 3 can be used to evaluate a given change in depth given a change in discharge. For example, we can let the right-hand side of Equation 3 represent the change equivalent to one standard error in log units and estimate the corresponding change or standard error in the depth. Some typical values are summarized in Table 1.

Table 1. Standard error of flood depths resulting from a given standard error in the flood discharge.

Standard error of discharge	**Standard error of depth**
0.107 log units, 25 percent	0.0428 log units, 9.9 percent
0.205 log units, 50 percent	0.082 log units, 19 percent
0.290 log units, 75 percent	0.116 log units, 27 percent
0.362 log units, 100 percent	0.145 log units, 34 percent
0.421 log units, 125 percent	0.168 log units, 40 percent

As shown in Table 1, a standard error of 50 percent in the discharge results in a standard error of about 19 percent in the corresponding depth. For depths of 10 feet, this would imply a standard error of 1.9 feet, for depths of 20 feet a standard error of 3.8 feet. This uncertainty is related only to the uncertainty in the flood discharge and does not consider the uncertainty in the hydraulic analysis such as estimation of n values, instability in the channel or modeling of bridges and culverts.

Discussion and Recommendations

Analysis of annual peak flow data at gaging stations indicate that the standard error of base flood discharges can be on the order of 75 percent in the semiarid west even when there are 50 years of data available. Most of the small streams in the west have less than 50 years of record so standard errors of base flood discharges can exceed 100 percent. Using the relation between depth and discharge (Equation 2), one can estimate the standard error in flood depths as a function of the standard error in flood discharges. For example, a 75-percent standard error in discharge results in a standard error of about 27 percent for the flood depth by assuming an average slope of 0.4 for the upper end of the depth-discharge relation.

The uncertainties in the base flood discharges and elevations associated with using regression equations and rainfall-runoff models are even higher than those based on gaging station data. The large uncertainty associated with the 1-percent annual chance (base) flood elevation suggests that the flood standard should not be increased but efforts should be expended in obtaining more accurate estimates of the current standard. In other words, the data do not support the use of a more restrictive standard. The following recommendations are offered as a way to use the current 1-percent standard and still improve floodplain management:

1. Increase funding to maintain the USGS streamgaging program and collect longer streamflow records that will reduce uncertainty in base flood discharges at gaging stations and in regional regression equations. Develop improved methods for estimating regional or generalized skew as part of Bulletin 17B analyses.

2. Update regional regression equations more frequently to reduce the standard error in base flood estimates. For example, USGS regression equations for 11 states are more than 20 years old (written communication, USGS, December 2003).
3. Update precipitation frequency studies in certain areas of the country to provide improved estimates for rainfall-runoff modeling. Increase the emphasis on calibrating rainfall-runoff models with gaging station data.
4. Incorporate the uncertainty in base flood discharges in floodplain management activities (not for flood insurance purposes) much in the same way that future-conditions hydrology is being considered (National Academy of Science (1978)).
5. Locate structures 2 or 3 feet or more above the base flood elevation, considering the uncertainty in the estimated elevation.
6. Evaluate the floodway concept and possibly eliminate it so that no development is allowed in the 1-percent annual chance floodplain.

The recommendation is to improve estimates of the current 1-percent standard to reduce the uncertainty in base flood elevations and to change certain philosophies of floodplain management but to maintain the current standard. As determined in the 1982 FEMA evaluation, there is no evidence to justify the expenditure of funds that would be necessary to convert to another standard (FEMA, 1983) and this is still true today. FEMA has produced over 100,000 map panels over the last 35 years and hundreds of flood insurance study reports. Updating the maps and reports to a new more restrictive standard is not warranted because of the large uncertainty in the current 1-percent standard. A better approach is to reduce the uncertainty in the current standard.

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RISK OF EXTREME EVENTS, RELIABILITY, AND THE FALLACY OF THE EXPECTED VALUE

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The expected value of risk is an operation that essentially multiplies the consequences of each event by its probability of occurrence and sums (or integrates) all these products over the entire universe of events. This operation literally commensurates adverse events of high consequences and low probabilities with events of low consequences and high probabilities. Indeed, extreme events with low probability of occurrence are each given the same proportional importance regardless of their potential catastrophic and irreversible impact. This mathematical operation is similar to the pre-commensuration of multiple objectives through the weighting approach.

This paper addresses the fallacy of the expected value *when it is used as the sole criterion for risk in decisionmaking*. (*Risk* is defined as a measure of the probability and severity of adverse effects [Lowrance 1976].) Experts who are becoming more and more convinced of the grave limitations of the traditional and commonly used expected value concept are augmenting this concept with a supplementary measure to the expected value of risk—the conditional expectation [Asbeck and Haimes, 1984, and Haimes 2004]. In this measure, decisions about extreme and catastrophic events are not averaged with more commonly occurring high-frequency/low-consequence events. Lowrance [1976] also makes an important observation on the imperative distinction between the quantification of risk, which is an empirical process, and the determination of safety, which is a normative process. In both of these processes, which are seemingly dichotomous, the influence and imprint of the analyst cannot and should not be overlooked. The essential role of the analyst, sometimes hidden but often explicit, is not unique to risk assessment and management; rather, it is indigenous to the process of modeling and decisionmaking [Kunreuther and Slovic 1996].

The major problem for the decisionmaker remains one of information overload: For every policy (action or measure) adopted, there will be a vast array of potential damages, as well as benefits and costs with their associated probabilities. It is at this stage that most analysts are caught in the pitfalls of the unqualified expected-value analysis. In their quest to protect the decisionmaker from information overload, analysts pre-commensurate catastrophic damages that have a low probability of occurrence with minor damages that have a high probability. From the perspective of public policy, it is obvious that a catastrophic dam failure, which might cause flooding of, say, 10^6 acres of land with associated damage to human life and the environment, but which has a very low probability (say, 10^{-6}) of happening, cannot be viewed by decisionmakers in the same vein as minor flooding of, say, 10^2 acres of land, which has a high probability of 10^{-2} of happening. Yet this is exactly what the expected value function would ultimately generate. Most important, the analyst's pre-commensuration of these low-probability of occurrence/high-damage events with high-probability, low-damage events into one expectation function (indeed some kind of a utility function) markedly distorts the relative importance of these events and consequences as they are viewed, assessed, and evaluated by the decisionmakers.

The distinction between *reliability* and *risk* is not merely a semantic issue; rather, it is a major element in resource allocation throughout the life cycle of a system (whether in design, construction, operation, maintenance, or replacement). The distinction between *risk* and *safety* is vital when addressing the design, construction, and maintenance of dams and levees, since by their nature such systems are built of materials that are susceptible to failure. The probability of such a failure and its associated consequences constitutes the *measure of risk*. Safety manifests itself in the level of risk that is acceptable to those in charge of the system. For instance, the selected strength of chosen materials, and their resistance to the loads and demands placed on them, is a manifestation of the level of acceptable safety. The ability of materials to sustain loads and avoid failures is best viewed as a random process—a process characterized by at least two random variables: *load* and *resistance*.

Unreliability, as a measure of the probability that the system does not meet its intended functions, does not include the consequences of failures. On the other hand, risk as a measure of the probability (i.e., unreliability) and severity (consequences) of the adverse effects is inclusive and thus more representative.

Clearly, not all failures can justifiably be prevented at all costs. Thus, system reliability cannot constitute a viable metric for resource allocation unless an *a priori* level of reliability has been determined. This brings us to the duality between risk and reliability on the one hand, and multiple objectives and a single objective optimization on the other.

In the multiple-objective model, the level of acceptable reliability is associated with the corresponding consequences (i.e., constituting a risk measure) and is thus traded off with the associated cost that would reduce the risk (i.e., improve the reliability). In the single-objective model, on the other hand, the level of acceptable reliability is not explicitly associated with the corresponding consequences; rather, it is predetermined (or parametrically evaluated) and thus, is considered as a constraint in the model.

There are, of course, both historical and evolutionary reasons for the more common use of reliability analysis rather than risk analysis, as well as substantive and functional justifications. Historically, engineers have always been concerned with strength of materials, durability of product, safety, surety, and operability of various systems. The concept of risk as a quantitative measure of both the probability and consequences (or an adverse effect) of a failure has evolved relatively recently. From the substantive-functional perspective, however, many engineers or decisionmakers cannot relate to the amalgamation of two diverse concepts with different units – probabilities and consequences – into one concept termed risk. In this sense, one may find basic philosophical justifications for engineers to avoid using the risk metric and instead work with reliability. Furthermore, and most important, dealing with reliability does not require the engineer to make explicit trade offs between cost and the outcome resulting from product failure. Thus, design engineers isolate themselves from the social consequences that are by-products of the trade offs between reliability and cost. The design of levees for flood protection may clarify this point.

Designating a “one-hundred-year return period” means that the engineer will design a flood protection levee for a predetermined water level that on the average is not expected to be exceeded more than once every hundred years. Here, ignoring the socioeconomic consequences, such as loss of lives and property damage due to a high water level that would most likely exceed the one-hundred-year return period, the design engineers shield themselves from the broader issues of consequences, that is, risk to the population’s social well-being. On the other hand, addressing the multiobjective dimension that the risk metric brings requires much closer interaction and coordination between the design engineers and the decisionmakers. In this case, an interactive process is required to reach acceptable levels of risks, costs, and benefits. In a nutshell, complex issues, especially those involving public policy with health and socioeconomic dimensions, should not be addressed through overly simplified models and tools. As the demarcation line between hardware and software slowly but surely fades away, and with the ever-evolving and increasing role of design engineers and systems analysts in technology-based decisionmaking, a new paradigm shift is emerging. This shift is characterized by a strong overlapping of the responsibilities of engineers, executives, and less technically trained managers.

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CONTEMPORARY RISK ANALYSIS AS THE FOUNDATION OF A NEW NATIONAL FLOOD STANDARD

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The Issue and Context

The 1% chance standard has not stemmed the growth in flood damage in the nation's floodplains. This increased damage may in part be because the 1% chance standard as presently applied has different interpretations depending on which dimension of floodplain management is being addressed. When delineating a floodplain, the standard generally translates to scribing a boundary that is the computed geographic limit of the flood. When specified in a zoning or land management regulation, the 1% chance standard is often augmented by an elevation buffer that then defines a geographic space within which development should be excluded. When used in the context of a target for, or describing the performance of, protective works, the 1% chance standard is often intended to communicate a level-of-protection. Depending on the specific protective measure, there is likely to be a buffer of flow, stage, or protective measure capacity included that is meant to ensure that the specified flood event is contained.

The risk of flooding to a location in the floodplain is different for each of these circumstances because of the buffers incorporated and uncertainty in data and computations are not directly accounted for. The consequence is that floodplain management based on the present 1% chance standard is inconsistent, perhaps costly and may result in poor to dangerous land use decisions. Would a higher standard change this situation? Perhaps; while it would result in flooding being less likely, the one weakness of using a simple flood standard would likely continue to prevail – lack of consistent, accurate representation of flood hazard to floodplain occupancy.

Another dimension of the 1% chance standard that is troublesome is that it is meant to establish a meaningful threshold of even greater floods. In use of the standard this way, neither the nature of greater floods, nor the consequence to floodplain occupancy of even greater floods is characterized. The consequence of floods exceeding the 1% chance standard now viewed as a threshold may be quite different, ranging from a slightly increased depth of flooding to rather quick, large and dangerous inundation. An improved standard should recognize this weakness.

An alternative concept worth considering is one that moves away from the single 1% chance event standard to a framework that more directly embraces principles of risk analysis. The fundamental underpinnings of risk analysis are the accounting for key elements in estimating flood risk (e.g. eliminating non-quantified buffers like levee freeboard and nominal rise in flood stage allowance), explicitly exposing and incorporating uncertainty in risk estimates, and reflecting consequences of exceedances.

Risk Analysis

Contemporary risk analysis as adopted and implemented by the US Army Corps of Engineers is analyzed and described by the National Research Council in 'Risk and Uncertainty in Flood Damage Reduction Studies', National Academy Press, 2000. Corps policy emphasizes the quantification of flood risk to floodplain property and occupants; quantifies how proposed project alternatives reduce flood risk and damages; and explicitly includes uncertainty in key factors in project formulation, evaluation, and reporting. Risk is used herein in the engineering context as a quantitative measure of the chance of flooding or chance of project capacity exceedance. Uncertainty as used herein reflects that we have imperfect or short record data and incomplete knowledge and analysis methods upon which to base estimates of risk. Key features of the Corps policy are: The use or reference to 'freeboard' or like buffers is eliminated; project performance is described by Annual Exceedance Probability (NRC – 'The probability that flooding will occur in any given year considering the full range of possible annual flood discharge') rather than level-of-protection (exceedance threshold for a single event); and the concept of residual risk – what remains of the risk and consequence of exceedance, is strongly emphasized. A byproduct of the Corps adopting risk analysis is that an alternative framework for levee certification determinations has been adopted in situations wherein risk analysis has been performed. The framework more directly accounts for site-specific flood characteristics and associated uncertainty, thus explicitly distinguishing risk differences between slow, flat, low variability flood potential and rapid, steep, high variability flood potential.

Genesis of a Framework for a New Flood Standard

A telling contribution of risk analysis to exposing the risk to floodplain occupancy is the documentation by NRC that the average AEP of floodplains behind a representative selection of levee projects sized to achieve the FEMA 1% chance standard is 1/230. Further, that the risk of exceedance for these levees varied from 1/100 to 1/10000 – hardly a standard, equitable treatment of the nations floodplains, nor an accurate representation of residual risk.

Research needs to be conducted to form a well structured framework for an improved flood standard based on the underpinnings of risk analysis. That said, with experience to date, it can be postulated here that the framework should include AEP as the risk standard (replacing the 1% chance standard with its variety of buffers), and that the standard should be scaled to local conditions, such as keyed to residual risk consequences of flood exceedances to include the characteristics of floodplain occupancy and the nature of protective measure capacity exceedance, if any exist. Consider, for example, a base standard AEP of 1/230 for unprotected floodplains for which stage increases for capacity exceedance is modest to moderate (this requires quantification – say floodplains with slow rising flood levels reflected in major rivers) scaling upward for floodplains for which stage increases are more extreme (say floodplains adjacent to steep mountainous streams or behind moderate height levees), scaling higher for highly developed floodplains behind high levees where overtopping could significantly endanger lives.

Attachment A

Annual Exceedance Probability (AEP) Maps

compiled by Chris Smemoe, Research Associate and Jim Nelson, Associate Professor, Brigham Young University; Darryl Davis, Corps of Engineers Hydrologic Engineering Center

When engineers design a levee or other flood control structure, they first determine the stream flow associated with, for example, the 100-year storm. Engineers then design a levee, a storm detention basin, or another structure that protects residences in the floodplain against this designated design stream flow event. Historically, for a levee, a few feet of "freeboard", or extra height, onto the levee is added to try to make sure the levee doesn't fail and to account for the uncertainty in knowing the actual flow rate for the design storm (Figure 1).

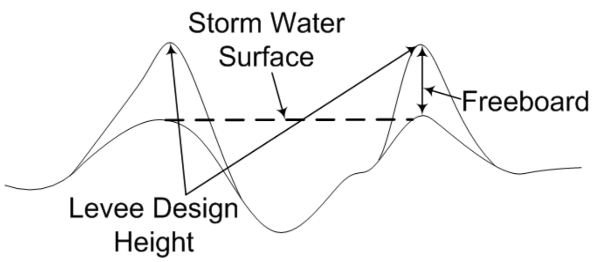

Figure 1: Designing a Levee

How much freeboard was added? Normally, an arbitrary amount of freeboard, such as two or three feet, was added. Often, the levee is costly to construct with the additional freeboard, and sometimes the levee fails or does not provide the level of protection required for a certain flood event.

Engineers have the technology to solve the problems associated with the current flood control structure design strategies. Instead of designing or certifying levees based on a single, 100-year storm event, levees should be evaluated based on the probability of failure or overtopping in any single year from the full range of potential floods. This probability is called the annual exceedance probability (AEP).

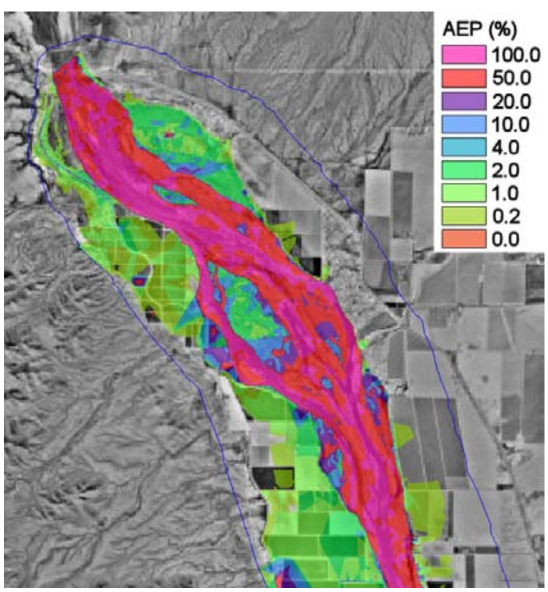

Figure 2: An AEP Map

Engineers can generate maps showing the AEP at any point in the floodplain (Figure 2). How is this done? Right now, the technology exists to automatically generate a single floodplain boundary map on a computer from hydrologic and hydraulic data. Using this same process, computers can use Monte Carlo simulations to generate maximum flood flows for the full range of potential floods and create a resulting floodplain map for each flow. These maps determine the effects of these flows on the levees or other structures before the floods actually occur. The computer creates an AEP map by taking these floodplain delineation maps and dividing the number of times each point on the floodplain floods by the total number of simulations. The result is then a new map which shows the probability of flooding in any given year.

Analysis methods are available that account for the possibility of failure of flood control structures (such as levees and detention basins) when creating an AEP map. Instead of certifying levees and flood control structures based on a single storm event, these structures should be evaluated based on the AEP concept. Additionally, the federal emergency management agency (FEMA) should develop policies that incorporate AEP maps into their flood insurance rate maps (FIRMs). This can be done by creating an AEP map instead of a single-line boundary as a FIRM, and then determining flood insurance rates based on the probability of flooding in any single year.

An AEP map can also be used in conjunction with a GIS database to accumulate expected damage for any return period to further quantify the total expected damage, or construct a graduated-risk insurance rate map, or if evaluating a control structure, the realized damage reduction benefits.

Attachment B

100-Year Flood Probability Maps

compiled by Chris Smemoe, Research Associate and Jim Nelson, Associate Professor, Brigham Young University; Darryl Davis, Corps of Engineers Hydrologic Engineering Center

US Federal Emergency Management Agency (FEMA) flood insurance rate maps (FIRMs) (Figure 3) show a single line delineating the floodplain boundary at the 100-year recurrence interval.

Because of natural variability and model uncertainty engineers cannot "truthfully" define the floodplain extents by a single line. In fact this leads to unreasonable litigation over extents because within limits of probability, engineers can use modeling input parameters to develop separate, yet reasonable results according to a clients self interests. However, with today's mapping and computer capabilities engineers can account for this uncertainty in the 100-year floodplain by creating a map depicting the range of possible floodplain boundaries for a 100-year event. This type of map is called a flood probability map (Figure 5).

Engineers create FEMA FIRMs by using average, or most probable values of hydrologic and hydraulic parameters for the floodplain to determine a single line depicting the 100-year floodplain boundary. On the other hand, a flood probability map is created by figuring out the flood extents using a range of hydrologic and hydraulic floodplain parameters.

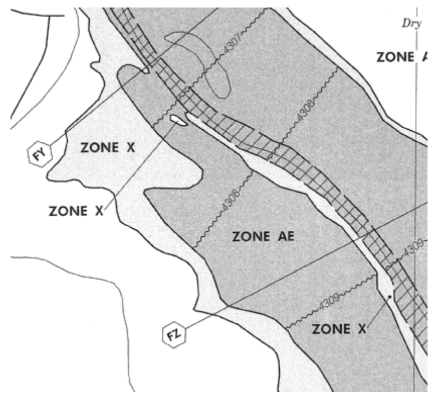

Figure 3: FEMA Flood Map

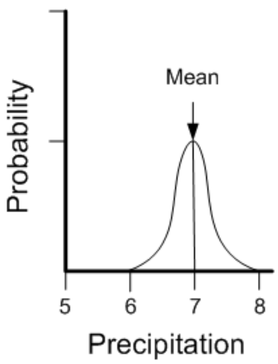

Figure 4: A 100-Year Precipitation PDF

Right now, technology exists to automatically generate a single floodplain boundary map on a computer from hydrologic and hydraulic data. Using this same process, computers can generate different hydrologic and hydraulic data scenarios for a single, 100-year storm event to generate a floodplain boundary for each scenario. To account for uncertainty, data scenarios are generated by sampling a probability density function (PDF) of required hydrologic or hydraulic parameters such as 100-year precipitation (Figure 4). The computer divides the number of times each point in the floodplain floods by the total number of simulations to generate a flood probability map. In the future, engineers will have tools that account for the possibility of failure of flood control structures (such as levees and detention basins) when creating a flood probability map. When certifying levees and other flood control structures, engineers should use flood probability maps such as these to determine the probability of flooding in each part of the floodplain, especially in populated areas. Additionally, FEMA should develop policies that incorporate this new flood probability map technology into their FIRMs. This can be done by creating a flood probability map (or an annual exceedance probability (AEP) map described in the accompanying document on AEP maps) instead of a single-line boundary as a FIRM, and then using "graduated" flood insurance rates based on the probability of flooding.

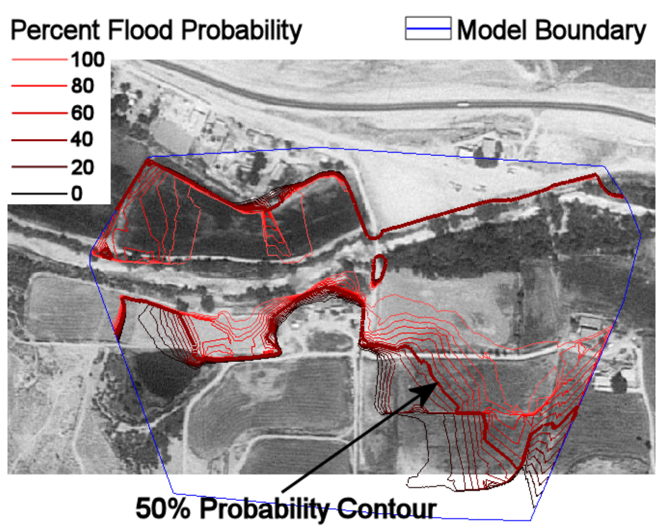

Figure 5: Flood Probability Map

ASSIGNING THE 1% FLOOD: LESSONS FROM RISK ANALYSIS

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Introduction. The concept of a peak annual flood with exceedance probability p=0.01 seems simple enough: when averaged over a long period of time, the frequency of floods larger than this ought to approach one per hundred years. There are well-known confusions caused by calling this, "the 100-year flood," but they are part of another discussion. The point here is that the increasing use of probabilistic risk analysis (PRA) in recent years has raised new questions about how we calculate annual risks – for example, of flooding or earthquakes or high winds – and what those risk numbers mean. The questions seem simple, but they are not simple to answer. What is of interest here is the relevance of such questions to national flood policy: to wit, exactly how big is a p=0.01 flood, how sure are we, how do we know, is the p=0.01 flood an innate property of nature?

Flood-risk management decisions must grapple with many uncertainties, for neither the probability of the peak annual flow nor the damages caused by it can be known with certainty. Water resources engineers were among the first within the technology policy community to come to grips with the probabilistic nature of natural hazards. What has changed today is that the advent of PRA has forced us to confront the meaning of the word *uncertainty* at a level of specificity which in earlier times was avoidable.

What does it mean to be uncertain? One could posit that most water resources professionals hold a Laplacian view of the world: We presume that the world is deterministic on a macro scale, and thus, knowable; but our information about the world is limited. Nature is deterministic, things occur necessarily according to natural laws, and knowing ever more about those laws and initial conditions allows ever more precise predictions. Thus, uncertainty is a result of limited knowledge rather than of innate randomness in nature.

We may model floods and other natural hazards as stochastic processes, but this is only a modeling convenience. In reality, these are deterministic processes, driven by natural laws and initial conditions of which we are not well aware. This recognition of parameter and model uncertainty as distinct from randomness but yet part of the assessment of risk is reflected in path breaking work by both the USACE for flood hazards (USACE 1996), and the Bureau of Reclamation for dam safety (Von Thun 1996). Yet more needs to be done.

The distinction between (1) natural variations over space and time on the one hand, and (2) lack of knowledge in the mind of the analyst on the other, has profound impact on the results of a risk analysis, and on the meaning that one ascribes to those results. Today, the former is often called *aleatory* uncertainty, and the latter *epistemic* uncertainty (Figure 1). These are reasonably pretentious, when the common terms *natural variation* and *knowledge uncertainty* would serve as well, but we seem stuck with them.

The distinction between aleatory and epistemic uncertainty is critical to accurately characterizing risk, but it complicates any analysis. For example, most uncertainties are a mixture of things, so how does one practically differentiate natural variation from limited knowledge? Since the two types of uncertainty reflect conceptually different things, how does

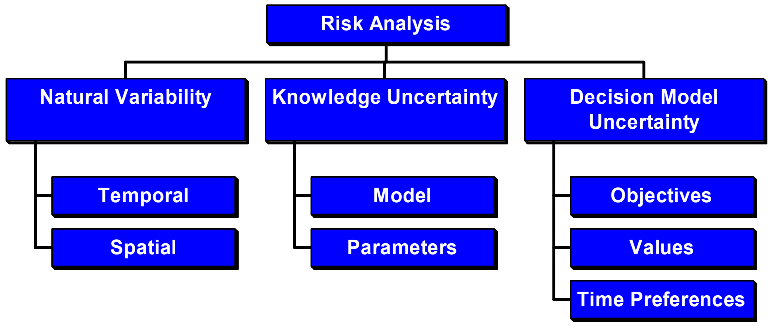

Figure 1. Categories of uncertainty in flood damage reduction studies (NRC 2000).

one quantify each? And, if probability theory is used as a measure of uncertainty, are different types of probability needed for different types of uncertainties? Can and should the two types of uncertainty be combined? If they can and should be combined, how does one do so? These issues are not limited to the analysis of flood damage; they are also important to dam safety, seismic hazard, structural reliability, wind threat, and other risks of concern to the built environment (Hartford and Baecher 2004).

Implications. Some implications of explicitly recognizing the differences between aleatory and epistemic uncertainty in flood risk assessments, and thus in quantifying the exceedance probabilities of floods of given include the following, but are by no means limited to them:

The p=0.01 flood is not a property of nature and is not necessarily annualizable. If uncertainties are to a great extent the reflection of limited knowledge, then a probability statement about a p=0.01 event has to do with uncertainties of the mind, not uncertainties of nature; thus such probabilities are not 'estimated' (implying that there is some real value), they are assigned.

There is no reason to think that the p=0.01 flood will be realized in the future time-series of floods. This builds on the last paragraph. Probability in many or most flood hazard studies is mostly a statement of limited knowledge, not predicted frequencies. Some of the uncertainties that influence this probability assignment have nothing to do with natural variations in time or space, but instead reflect model inaccuracies or data limitations for estimating parameters.

Aleatory and epistemic uncertainties need to be combined in marginal probabilities for the purposes of risk assessment. If the underlying basis of uncertainty in risk assessments is caused by limited knowledge, it makes no sense to separate out a "best estimate" of flood *frequencies* from confidence bounds that surrounding that estimate. The complete set of uncertainties ought to be integrated together in a predictive probability in conformance with Bayesian methodology (Al-Futaisi and Stedinger 1999). This also eliminates confusing references to "conditional non-exceedance probabilities", and other convoluted descriptions of the interplay of aleatory and epistemic uncertainties that make little sense to engineers, and absolutely no sense to the public. These marginal probabilities will imply higher values of risk than traditional 'best estimate' do, because they incorporate a more complete set of uncertainties.

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Part 3

Implementation of the 1% Chance Flood Standard

LESSONS LEARNED FROM THE CRS RELATED TO THE 1% CHANCE FLOOD

Jerry Foster
Insurance Services Office

Background: The Community Rating System (CRS) is designed to encourage and reward activities that exceed the minimum requirements of the National Flood Insurance Program. The reward is a reduction in premium rates for flood insurance policyholders in the community.

The CRS credits a range of local (and state) activities that operate to reduce flood losses, promote flood insurance purchase, and facilitate accurate insurance rating. The CRS credits 18 activities, organized under four general series, as listed in the box to the right. Each of the 18 activities has up to 13 elements that help calculate how many points the community's effort is worth. The points are used to determine the community's CRS class. Modeled on the fire insurance rating system, a Class 1 community has the greatest premium discount (45% in the CRS) and a Class 10 community receives no discount.

The rating formulas, verification procedures, credit criteria, and documentation requirements are described in more detail in the *CRS Coordinator's Manual* and on the CRS website, http://training.fema.gov/EMIWeb/CRS/

To date, of the 20,000 communities in the NFIP, over 1,000 are participating as CRS Class 9 or better. They come from all 50 states. They range from small towns to metropolitan counties. While they represent only 5% of all the NFIP communities, they account for the bulk of the nation's flood problems and 2/3 of all flood insurance policies.

CRS Activities

300 Public Information Activities
- 310 Elevation Certificates
- 320 Map Information
- 330 Outreach Projects
- 340 Hazard Disclosure
- 350 Flood Protection Information
- 360 Flood Protection Assistance

400 Mapping and Regulatory Activities
- 410 Additional Flood Data
- 420 Open Space Preservation
- 430 Higher Regulatory Standards
- 440 Flood Data Maintenance
- 450 Stormwater Management

500 Flood Damage Reduction Activities
- 510 Floodplain Management Planning
- 520 Acquisition and Relocation
- 530 Flood Protection
- 540 Drainage System Maintenance

600 Flood Preparedness Activities
- 610 Flood Warning Program
- 620 Levee Safety
- 630 Dam Safety

Activities related to the 1% chance flood: Community participation in the CRS is voluntary. Similarly, communities may pick which activities and elements they want to implement and have credited. Three of the creditable elements can be directly related to the 1% chance flood:

- The standards used for regulatory floodplain maps,
- The protection level for all new construction, and
- The protection level for critical facilities.

Mapping standards: Activity 410, Additional Flood Data, credits developing floodplain maps and flood data in areas where FEMA did not provide such data or adopting floodplain maps and studies that were prepared to higher standards than the NFIP criteria.

Of the 1,001 participating communities, 274 receive some credit under Activity 410. Unfortunately, the database does not reveal what higher mapping standards, if any, were used. We do know that some of the credited maps were prepared using future conditions hydrology and 112 of the 274 communities use a more restrictive floodway mapping standard than the NFIP's one foot allowable surcharge.

Freeboard: Freeboard is one of the elements in Activity 430. A freeboard requirement adds height above the base flood elevation to provide an extra margin of protection to account for waves, debris, miscalculations, or lack of data. A freeboard requirement of 1 foot would require the same standards at 1 foot above the base flood elevation.

Freeboard is the most common of the 13 higher regulatory standards credited in Activity 430:

79 communities receive credit for up to 1 foot of freeboard
295 communities receive credit for 1−2 feet of freeboard
110 communities receive credit for 2−3 feet of freeboard
33 communities receive credit for 3 or more feet of freeboard
517 communities require new construction to exceed the 1% flood elevation standard

Protection of critical facilities: "Critical facilities" are not strictly defined by the CRS. Generally, they fall into two categories:

- Buildings or locations vital to the emergency response and recovery effort, such as police and fire stations and telephone exchanges and
- Buildings or locations that, if damaged, would create secondary disasters, such as hazardous materials facilities and nursing homes.

Activity 430 credits local regulations that require new critical facilities to be either prohibited from the floodplain or protected to at least the 0.2% chance (500-year) floodplain. Currently, 49 CRS communities are receiving credit for this element. All but five of them are also receiving freeboard credit.

Conclusion: The CRS was not designed to measure communities' concerns with the 1% flood standard. The database does not readily identify communities with a desire to use another or more restrictive mapping standard. However, the program does credit activities that exceed DHS/FEMA's 1% flood mapping criteria or that require new construction to be protected to a higher level:

- 27% of the CRS communities (274) are regulating floodplains or using data not supplied by DHS/FEMA.
- 11% (112) want better protection from future floodplain encroachment than provided by the NFIP's 1 foot surcharge standard.
- 52% of the CRS communities (522) require new buildings or critical facilities to be protected to a level higher than the 1% chance flood.

It should be noted that it is likely that more communities are implementing these activities than shown by these numbers. For a variety of reasons, communities do not apply for all the credits they deserve. In addition many other communities implement these activities, but do not participate in CRS for various reasons.

In sum, over half of the CRS communities have concluded that the minimum NFIP floodplain management requirements do not adequately protect future development. As a remedy, they have adopted their own higher mapping or regulatory standards to ensure that new development is protected to a higher level.

POTENTIAL EFFECTS OF CHANGING THE 1% CHANCE FLOOD STANDARD ON STATE DAM SAFETY PROGRAMS

Keith Banachowski
for the Association of State Dam Safety Officials

The Association of State Dam Safety Officials (ASDSO) is a national non-profit organization of state and federal dam safety regulators, dam owners and operators, engineering consultants, manufacturers and suppliers, academia, contractors and others interested in dam safety. The association has over 2000 members. It is ASDSO's mission to advance and improve the safety of dams by improving the efficiency and effectiveness of state dam safety programs, increasing public awareness and education of dam safety, and facilitating exchange of dam safety information. From providing networking support for the dam safety community, to holding continuing education, to offering tools to dam owners, this association is dedicated to improving dam safety in the United States.

Dams are innately hazardous structures. Failure or mis-operation can result in the release of the reservoir contents - this includes water, mine wastes or agricultural refuse - causing negative impacts upstream or downstream or at locations remote from the dam. Negative impacts of primary concern are loss of human life, economic loss including property damage, lifeline disruption and environmental damage.

State governments have regulatory responsibility for 95% of the approximately 78,000 dams within the National Inventory of Dams. There are approximately 10,000 state-regulated "high-hazard" potential dams in the U.S. "High-hazard" is a term used by a majority of state dam safety programs and federal agencies as part of a three-pronged classification system used to determine how hazardous a dam's failure might be to the downstream area. As a general trend, the number of high-hazard dams is increasing - not because more high-hazard dams are being built, but because more development is occurring downstream. Dam safety regulators generally have no control over local zoning issues or developers' property rights.

State dam safety programs vary in authority, but program activities typically include 1) safety evaluations of existing dams, 2) review of plans and specifications for dam construction and major repair work, 3) periodic inspections of construction work on new and existing dams, and 4) review and approval of emergency action plans. Beyond these basic commonalities, the state programs have significant differences. State dam safety programs exist in various governmental structures and can be coupled with environmental, water supply, and floodplain management programs. Staff levels vary from less than 5 to over 60, with most programs having less than 10. Dam safety administrative rules, policies, and engineering standards vary from state to state. For example, a high-hazard dam in Michigan must have sufficient discharge/storage capacity to safely pass a 0.5% chance flood (200-year flood), while the same dam Ohio must safely pass the Probable Maximum Flood, which is several times larger. Another significant difference among the states is the acceptance of risk-based design.

Dam safety engineering uses different size flood events (design floods) to design different parts of the structure. Design floods are used for two main purposes: 1) determining the service spillway discharge capacity for the purpose of limiting flow frequency of a potentially erodible secondary spillway and 2) determining the dam's overall flood discharge/storage capacity for the purpose of preventing the dam from collapsing during large floods. For service spillway design, the 1% chance flood is typically the largest design flood that is used. For overall flood discharge/storage capacity design, the 1% chance flood is the smallest design flood that is used. Some states allow low-hazard and smaller significant-hazard dams to use the 1% chance flood for dam flood capacity. For significant- and high-hazard dams, most states use design floods well in excess of the 1% chance flood.

A brief, informal survey of the state dam safety programs was conducted in July 2004 concerning the effects of FEMA changing the use of the 1% chance flood as a standard. The survey concluded a change would have little direct impact on state dam safety programs. As an indirect impact, some states that more frequently use the 1% chance flood in dam design reported that they would likely review their design standards to determine whether their standards should change to be consistent with the FEMA standard. Another indirect impact would be a general change in the downstream hazards, and potentially classifications, of some dams.

Development in floodplains is occurring downstream of dams. Regardless of the level of protection of these developments, ASDSO has noted an increasing trend in reclassification of low- and significant-hazard dams to high-hazard. Reclassification often requires a dam owner to perform additional engineering studies and physical improvements, which in turn requires allocation of regulatory resources from the state's dam safety program. It can be concluded that an increasing number of high-hazard dams means an increasing strain on state dam safety programs. The question becomes… how much would a change in the FEMA flood standard change this trend of increasing numbers of high-hazard dams? Suppose that there is a reduction in the FEMA flood standard from the 1% chance flood to the 4% chance flood. Subsequent development would be at lower elevations. Lower building elevations would not change the impact of failure of a large dam, but for failure of a small- or intermediate-size dam, lower building elevations could make a difference, and result in reclassification. While federal agencies tend to regulate very large structures, state dam safety programs regulate structures of various sizes including many small- and intermediate-size dams. Changing of the 1% flood standard could cause indirect, long-term strain on state dam safety programs because of reclassification of small- and intermediate size dams. The amount of strain would vary from state to state and would depend upon the amount of change of the flood standard and the particular situation of the state. For several states, the strain could be minimal.

(Statistics and portions of text are taken from the ASDSO web site)

USE OF THE 90TH PERCENTILE FLOOD ESTIMATE

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Flood hydrology typically uses the "best" estimate of the 100-year flood produced by various techniques. The "best" estimate of the 100-year flood is the flood peak which is too high 50% of the time and too low 50% of the time.

The USGS has developed regression equations for most areas of the US. These regression equations use data for a variety of hydrologic parameters in a region of a state to estimate peak flows at ungaged locations in that region. The regression equations for a region produce "best" estimates for flood peaks with various recurrence intervals and standard errors of prediction that indicate how well the regression equation predicts the estimates based on data at the gages.

Use of the standard error of prediction (SEP) allows conversion of the "best" estimate (the 50^{th} percentile) to other percentiles of confidence. For this paper, the "90^{th} percentile" flood peak is that peak flow which is too high 90% of the time (and too low 10% of the time).

This analysis used the USGS equations for 163 river gages in 17 regions in 7 states to analyze the 50^{th} percentile floods and the 90^{th} percentile floods. Flood peaks and flood elevations were estimated for the 25-year flood and the 100-year flood at each location.

The river gages selected met two criteria: they were in regions where the regression equations were based on the single parameter of drainage area; and the rating curve extended to at least the best estimate of the 25-year flood.

Comparison of the 50^{th} Percentile and 90^{th} Percentile 100-Year Floods:

On the average, the 90^{th} %ile flood peak was 132% higher than the "best" estimate, the 50^{th} %ile flood peak. The increase ranged from 47% to 600%. The increase in peak flow is a function of the SEP. The higher the SEP, the larger the increase.

On the average, the peak flood elevation for the 90^{th} %ile 100-year flood was 3.7 feet higher than the peak flood elevation for the "best" estimate, or 50^{th} %ile 100-year flood. This "best" estimate is the Base Flood Elevation (BFE) used by the NFIP.

The difference in flood elevations is a function of both the increase in peak flow and the stage-discharge relationship, or rating curve, at the river gage. The stage discharge relationship is a function of the shape of the river's cross section at the gage site, so it varies a lot from gage to gage, even within a region.

Impact of the Use of the 90th Percentile Flood for Floodplain Management

Use of the 90th %ile flood for floodplain management would cause, in most cases, some dramatic changes:

- Flood peaks would increase significantly. For all regions with USGS regression equations, increases in peak flows would range from about 40% to over 1,000%.
- Flood elevations would increase significantly, with an average increase between 3 and 4 feet.
- Increased flood elevations would mean wider floodplains. This increase in width would be a function of the shape of the cross section. No estimate is offered for this increase.
- Increased flood peaks would mean wider floodways. In general, the floodway width would increase somewhat less than the percent increase in flow, because the river channel would continue to carry most of the water. Where the floodway is currently entirely within the channel, there might be no increase in floodway width.

Comparison Between the 90th %ile 25-Year Flood and the Base Flood

At 98% of these gage locations, the 90th %ile 25-year flood is larger than the 50th %ile 100-year flood. That means that, in general, we expect that more than 10% of all development built at the Base Flood Elevation to actually be below the 25-year flood elevation.

For example:

War Eagle Creek near Witter, AR has a drainage area of 22.4 square miles. Using the USGS regression equations for that location, we get:

25-year flood peak = 9,400 cfs ("best" estimate)
100-year flood peak = 13,000 cfs ("best" estimate, Base Flood per NFIP)
25-year flood peak = 14,800 cfs (90th %ile estimate)
100-year flood peak = 20,200cfs (90th %ile estimate)

There is a 10% chance that the 25-year flood (14,800 cfs) is larger than the Base Flood (13,000 cfs).

Using the rating curve at the gaging station, we get the following:

Flood elevation for 9,400 cfs = 16.5 feet (25-year, 50%)
Flood elevation for 13,000 cfs = 18.4 feet (100-year, 50% (BFE))
Flood elevation for 14,800 cfs = 19.2 feet (25-year, 90%)
Flood elevation for 20,200 cfs = 21.5 feet 100-year, 90%)

The Base Flood Elevation is 18.4 feet. In 10% of all floodplains in this region where the drainage area is 22.4 square miles, the 25-year flood elevation is actually 19.2 feet or more. We need to build at 21.5 feet to be 90% sure that the building is at or above the 100-year flood.

Something over 10% of the buildings in this region of Arkansas that have been built at the BFE will be flooded, on the average, every 25 years. The flood hazard will actually be greater because development will be allowed to encroach on a floodway designed for a smaller flood. With maximum encroachment, 10% of the flood elevations for the 25-year flood will be at or above 20.2 feet, or 1.8 feet above the BFE.

If they were built at the elevation of the 90th %-ile 100-year flood, perhaps 3.1 feet higher, about 10% of them would be flooded, on the average, once every 100-years.

Discussion of These Results

There are numerous faults with the methods used in this analysis. They include:

- The gages used for this analysis cannot be considered representative because they were not sampled randomly. They were selected because they were fairly easy to analyze and the data needed for the analysis were readily available. This affects the average increase in flood peak flows and increases in flood elevations in ways that cannot be predicted.
- For about two-thirds of these gages, the rating curve had to be extended to estimate the elevation of the 90th %-ile flood. This makes the flood elevations questionable.
- River gage locations are selected because they are in confined reaches of a river, such as at bridges or in canyons with steep sides. The wider the flooded area, the less increase there is in flood elevation for a given increase in flow. This means that the average increases in flood elevations are probably overstated relative to all floodplains.

This analysis was done to provide a very rough idea of the impact of using a safer flood for floodplain management purposes. Similar analyses could be done using a 75th %ile flood, a 95th %ile flood or any other flood.

The other commonly used method for flood hydrology is rainfall-runoff modeling. Errors in rainfall used in these models, along with errors in % impervious surface, travel times, etc. combine to create standard errors that are probably larger than those from the regression equations.

The only real way to know the effects of this methodology for flood hydrology is to run some real hydraulic models using the 100-year 50th %ile flood and the 100-year 90th %ile flood and compare the results. These analyses should include the floodway analysis. The results can be used to compare flood elevations, floodplain widths and floodway widths for "best estimate" base floods and 90th %ile 100-year floods.

The only certain way to reduce flood damage is to build further from the source of the flood and build higher. Use of the 90^{th} %ile flood instead of the “best estimate” will accomplish this.

The way to reduce the standard error of prediction, or SEP, is to have more data and/or spend more time and money analyzing the available data.

ARE WE REALLY MAPPING/MANAGING THE 1% CHANCE FLOODPLAIN?

Alan Lulloff
Association of State Floodplain Managers

Flooding has been and continues to be the nation's most costly natural disaster. In an attempt to reduce flood damages, Congress passed the National Flood Insurance Act of 1968. This legislation established the National Flood Insurance Program (NFIP) directing the U.S. Department of Housing and Urban Development (HUD) to map flood hazard areas. The intent was to provide flood insurance for existing structures at risk and zoning to prevent new development in flood hazard areas. However, flood losses continue to rise. This paper will discuss whether the nation is really mapping or managing the 1% chance floodplain.

Many areas at risk have not been mapped

The NFIP Act required maps be developed for all flood hazards. The USGS 1:100,000 Scale National Hydrography Dataset identifies 3,500,000 miles of streams in the U.S. While the federal government has no data set identifying the miles of stream for which flood hazard maps have been developed; by looking at a couple of examples – Nebraska and Michigan – it is clear that many flooding hazards have not yet been mapped.

- Nebraska - 40 of the 93 counties in the state have no NFIP flood hazard maps. Nebraska is not a highly populated state; however some incorporated communities in these unmapped counties have concentrations of population at risk.

- Michigan – The federal government initially developed two types of maps – Flood Insurance Rate Maps (FIRMs) and Flood Hazard Boundary Maps (FHBMs). The Flood Hazard Boundary Maps were developed without the benefit of an engineering analysis and were only estimates of the flood hazard that existed in that community. The intent was to eventually conduct engineering analyses in these communities and upgrade these maps to a FIRM. In the 1980s, the NFIP made a policy decision to convert the Flood Hazard Boundary Maps to FIRMs without conducting an engineering analysis – the maps were basically just republished with a new name and new date. Michigan objected, citing concerns that the FHBMs were inadequate. As a result, nothing was done and several hundred communities in Michigan now have no flood hazard mapping.

The NFIP has developed no minimum standard defining which flooding sources warrant a Flood Insurance Rate Map. Without such a standard, the Flood Map Modernization initiative will not fully address this problem. We must ask if the lack of mapping destroys our ability to determine whether the 1% chance flood standard is effective?

Inaccurate maps lead to poor management and lack of credibility for flood programs

Due to the lack of topographic data when the FIRMs were developed and the manual cartographic methods used to develop them, many of the FIRMs developed do not accurately represent the hazard.

Poor quality flood maps causes local officials and riparian landowners to lose confidence in programs and agencies attempting to regulate them. Local officials are not willing to enforce floodplain regulations since neither the property owner nor local officials think the maps are accurate. Landowners do not trust government when they are told flood insurance is needed when their building may be 25-40 feet above the river.

In 1978, twelve years after passing legislation requiring floodplain zoning in Wisconsin, the Wisconsin Department of Natural Resources (WDNR) conducted a survey of communities in the western portion of the state to evaluate community implementation of floodplain zoning. By far the major compliant voiced by communities was the quality of the mapping. In 1995, WDNR received funding from FEMA to remap a county that had purchased countywide 2-foot contour maps. The old maps identified 5,700 structures in the floodplain. The new maps that more accurately matched topography showed that 2,400 (42%) of these structures were actually not in the 1 % chance floodplain. More significantly, the updated maps showed that there were 1,800 structures in the floodplain that the old maps did not show at risk. Prior to the new mapping, the owners of these structures were not aware of the hazard and the county zoning office was permitting the construction of new structures in these flood hazard areas.

Current maps also do not take into account future development, which will increase the runoff, and thus future flood levels. Charlotte/Mecklenburg showed that flood levels in some of their rapidly developing streams would increase 4 to 9 feet when that watershed was fully developed. So their maps show flood levels based on future development. Without that, property owners who built at today's flood level would experience devastating floods as the watershed became developed within a decade or so.

On the other side of this issue, landowners on high ground must go through bureaucratic red tape and incur substantial personal expense to prove something that with common sense seems obvious: their house – 40 feet above the stream - is not in the floodplain. Following is an excerpt from a letter I received on August 9, 2004, from Wisconsin State Senator Ron Brown that illustrates this issue:

> "Earlier this month, one of my constituents from Buffalo County approached me about the difficulties she has experienced in trying to remove her property from special flood hazard area (SFHA) designation on the existing FEMA map. Her difficulties in filing the necessary Letter of Map Amendment (LOMA) stem in large part from the lack of base flood elevation information for the area. Compounding that frustration is the fact that the property in question is situated on a hillside and both the zoning administrator and GIS coordinator for the county agree that the residence should not be shown in the 100-year floodplain. Local officials believe the current map contains numerous inaccuracies."

Instances such as this become poster children for the property rights groups and spawn legislation that rolls back state standards that attempt to improve upon the federal minimum standards. The issue is not only the unnecessary expense for property owners, but the feeling they are being unfairly imposed upon by government programs. Few Americans would argue against reducing flood damages, but those programs (maps, regulations and insurance requirements) must be done with accuracy and fairness or support for those programs and belief that property is really at risk are in jeopardy.

Conclusion

It might be fair to say that we really don't know whether we have been using the 1% chance standard to reduce flood losses in the nation. Studies of the population at risk that need mapping and the accuracy of the mapping, with some extrapolation to the nation would be helpful in such a determination. The studies need to also factor in the different means of implementation states and communities in the nation are using. For example, a number of states require 2 feet of freeboard above the 1% flood level for the first floor. Many also allow zero rise from floodway encroachment, as opposed to the one foot rise allowed by the NFIP. In those instances, do rules like these make up for the inaccuracies of the maps?

Studies to determine to what level of protection the nation is really managing for its new and substantially improved development will assist us in determining the best approach to future flood loss reduction.

BRIDGING THE GAP BETWEEN FLOODPLAIN MANAGEMENT AND FLOOD FORECASTING— THE RELATIONSHIP BETWEEN THE FEMA 1%-CHANCE FLOOD AND THE NOAA NATIONAL WEATHER SERVICE FLOOD CATEGORIES

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Doug Marcy
NOAA Coastal Services Center

Glenn Austin
National Weather Service

Margaret Davidson
NOAA Coastal Services Center

Background

The Federal Emergency Management Agency (FEMA) is responsible for administering the National Flood Insurance Program (NFIP), as well as programs that provide assistance for mitigating future damages from natural hazards. The 1-percent-chance flood standard has been used since the inception of the NFIP for floodplain management purposes in all of the 19,200 participating communities that have been issued flood hazard maps. The 1-percent-chance flood (or 100-year flood) represents a magnitude and frequency of flood waters that has a 1 percent statistical probability of being equaled or exceeded in any given year and is identified through hydrology and hydraulic analyses in a flood insurance study (FIS). Flood insurance rate maps (FIRMS) produced from a FIS provide insurance companies and homeowners with inundation boundaries for the 1-percent-chance flood and have become a widely used planning and mitigation tool for floodplain management.

As part of its mission to provide weather, water, and climate forecasts and warnings for the United States, the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) offers flood forecast information in a variety of formats including text products, hydrographs, and experimental maps. The flood categories used by the NWS at most forecast points are flood stage, moderate, major, and record flooding. Each category has a definition based on property damage and public threat. The severity of flooding at a given river stage differs along the corresponding river reach due to varying channel/bank characteristics, local topography, and possible flood control structures. The stage value assigned for a given flood category is associated with a water level where significant flood impacts occur. By assigning flood categories based on severity of pending risk, the NWS issues appropriate (minor, moderate, and major) flood warnings to emergency/floodplain managers and the public to help minimize losses and damage during flood events.

Improving the Communication of Flood Risk

A major challenge facing both FEMA and the NWS is to educate both emergency/floodplain managers and the public about the way both agencies convey flood risk, primarily through graphical products. Although the 1-percent-chance flood standard is commonly used for floodplain management, the need for early warnings during flood events necessitates an incremental warning system to get people and property out of harms way. Because river stages can be translated to a common vertical datum, direct comparisons between both agencies' products are possible. Questions will undoubtedly arise as to why there are differences between the 1-percent-chance flood and the NWS flood warning categories. One approach to diffusing this potential confusion and to highlighting the benefits of each may be to provide products for the NWS flooding definitions as they compare to the FEMA 100-year flood designations. To identify and convey varying degrees of risk and vulnerability, the NWS is now producing experimental graphical depictions of flood categories. If both NWS warning categories and the FEMA 100-year flood stage are combined into one product, the resulting graphic or map can then be used to clearly illustrate the relationships between the FEMA 100-year flood and the NWS flood warning categories.

Because incremental warning stages allow more time for communities to respond to the threat, stages that trigger the NWS flood categories for a given river reach will be activated before rising waters approach the FEMA 100-year stage. Major flooding at NWS forecast points is less than the FEMA 100-year stage, and the magnitude of the difference between the two varies greatly at forecast locations. A typical example is shown for Rocky Mount, North Carolina (Figure 1). The NWS defines major flooding to begin at 105.0 ft mean sea level (MSL) and the FEMA 100-year stage is 116.0 ft MSL (a difference of 11.0 ft). Based on the NWS definition of major flooding, extensive inundation of structures and roads begins when the stage reaches 105.0 ft, and evacuations of people and/or transfer of property to higher elevations should occur – long before the 100-year stage is reached.

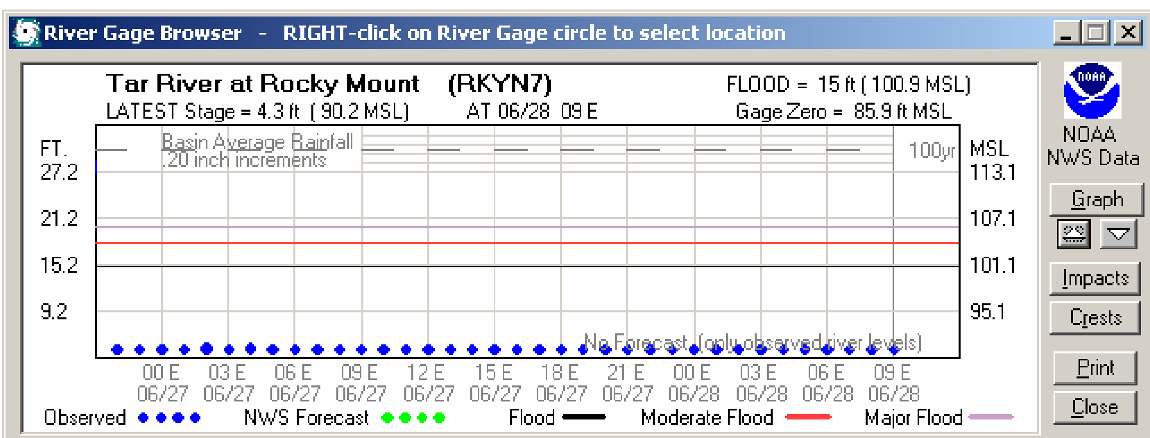

Figure 1: *Example hydrograph from HURREVAC shows river stage versus time for the Tar River in Rocky Mount, North Carolina. The left vertical axis shows the river gage height; the right vertical axis shows the corresponding water surface elevation at MSL. NWS categories for flood stage, moderate, and major flooding are depicted as solid horizontal lines across the graph. The FEMA 1-percent-chance flood is depicted as a dashed line at 116.0 ft MSL.*

The NOAA Coastal Services Center and the NWS have been working with FEMA Region IV to incorporate inland flooding information into new releases of FEMA's hurricane evacuation planning decision-support tool (HURREVAC). The most recent release of HURREVAC (2004 Version 3.0.8) includes flood forecast points from the NWS for North Carolina and Florida. Forecast information is presented in the form of hydrographs, as well as historical impacts and crests. These hydrographs depict relationships between the FEMA 1-percent-chance flood and the NWS flood categories. Funding for adding forecast points from Texas to Maine, Puerto Rico, and the U.S. Virgin Island is planned for release prior to the 2005 hurricane season.

FEMA Region IV has asked the NOAA Coastal Services Center to assist with providing inundation maps of the 1-percent-chance flood at NWS forecast locations in the Southeastern United States. These maps will be included as static images in future releases of HURREVAC as a reference for emergency managers. Future enhancements may include mapping the NWS flood categories (stage-inundation map shown in Figure 2), illustrating the relationship between the FEMA 1-percent-chance flood and NWS flood forecasts.

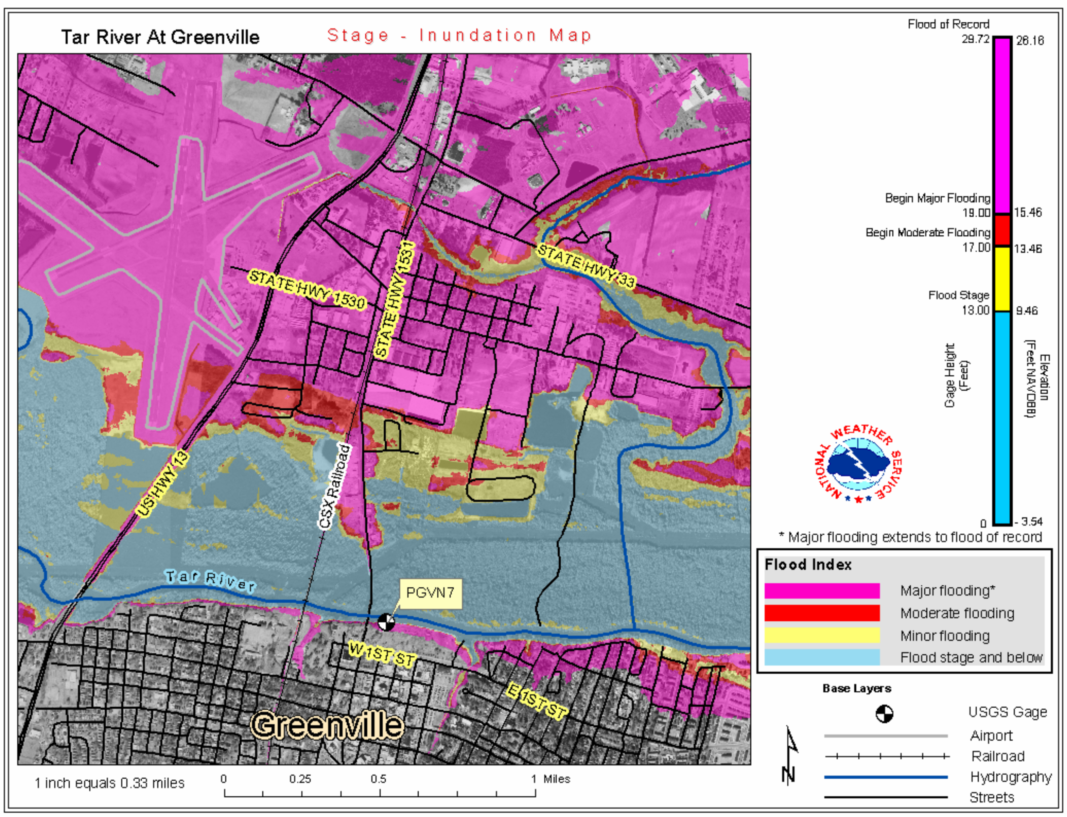

***Figure 2:** Example stage–inundation map (NWS experimental product) shows NWS river stage flood categories mapped as inundation layers for the river forecast point in Greenville, North Carolina. NWS categories for flood stage (minor), moderate, major, and record flooding are depicted as semitransparent inundation polygons of varying color.*

Conclusions

New technologies are being developed with the potential to disseminate critical information in efficient and illustrative formats. FEMA and NOAA are exploring various possibilities of combining flood risk information into graphics, maps, and decision-support tools to better inform emergency/floodplain managers and the public. One of the first attempts is showcased in FEMA's decision-support tool, HURREVAC. NWS flood categories and the FEMA 100-year flood designations are included in this product. By coupling NWS and FEMA products, emergency/floodplain managers will be in better position to respond to emergencies. The resulting team effort may provide simplified coordination and delivery of services to those in need and provide a unified approach to coping with flood-related disasters. The linkage could help floodplain managers and emergency managers better assess the effects of forecast floods on critical facilities. It could also help optimize community land use, development, storm water management, and zoning strategies. The end result would likely be reduced flood mitigation, damage, and disaster recovery costs.

A PERSPECTIVE ON FLOODPLAIN MANAGEMENT PRACTICES FROM THE HYDROLOGIC WARNING COMMUNITY

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Background

The National Hydrologic Warning Council (NHWC) represents three user groups based in the west, southwest and eastern United States. The communities that make up these organizations have acquired technologies (ALERT, IFLOWS, GOES, others) for detecting floods and flood threats in real-time. Many have also developed sophisticated local flood warning programs (LFWP) to supplement services provided by the National Weather Service (NWS). By 2005, the NHWC is expected to incorporate and formally establish itself as one organization that represents the interests of entire hydrologic warning community. The user groups will remain integral members of the NHWC focusing more on regional issues and specific technologies, while their NHWC affiliation directs its efforts nationally.

Some Parallels Between Flood Warning And Floodplain Management

In the mid to late 1960s, a few flood forecasters began talks with some willing private businesses. These talks lead to development of affordable flood detection technologies, but the impetus for implementing these ideas was driven by disasters—floods and fires. After the devastating 1972 Rapid City flash flood, the push for deployment was on. Recent wildland fires in Monterey County, California gave that community the incentive to invest in this new technology. By 1975, San Diego County had installed the first countywide ALERT system in the nation. Then in 1976 the Big Thompson Canyon flash flood occurred downstream of Estes Park, Colorado. Communities like Boulder and Denver acted quickly following California's lead. Now after nearly 30 years, local flood warning systems continue to be a popular choice, supplementing successful and sometimes less-than-successful floodplain management (FPM) programs.

Our nation's flood defense strategies have been similarly driven by disasters and the economic impacts of those disasters. When Congress passed the 1936 flood control act it seemed like the right thing to do, and large federally funded public works projects did help bring our country out of the Great Depression. After 30 years of this activity, economic realities caused Congress to take another look at the problem and the NFIP was the result. The 1% regulatory flood standard was adopted as a reasonable "minimum" economically based standard and for the next 30 years large investments were made to achieve desired goals, including engineering efforts to define "special flood hazard areas." Now 30 years later we are looking at the economics once again and wondering why we appear to be in a similar predicament.

Communities invest in early flood detection/warning programs because: 1) they have experienced at least one severe flood and 2) implementing remedial measures may be judged prohibitively expensive or politically unacceptable. Early flood warnings empower people to act. Appropriate timely actions save lives and can prevent or greatly limit property damage given enough lead-time. The cost effectiveness is this approach has been demonstrated and its price tag more easily fits local budgets.

A parallel that can be drawn between LFWP development and FPM practices is that both activities have been driven largely by disasters and the economics associated with mitigating future disasters. Both practices are typically classified as non-structural in nature, although FPM in the broader sense includes a structural component. The economics of LFWP after 30 years suggests a positive outcome, while FPM economics are being questioned. With respect to the larger view of FPM, LFWP is one component.

Some Thoughts To Contemplate

Use of the 1% flood standard has not failed everywhere. Before we seriously consider replacing this standard with something more restrictive, we should very carefully assess why this standard has "failed," if in fact it has. How did our nation arrive at this "undesirable" condition of "unacceptable" flood losses? How is "unacceptable" defined? We need better metrics and more research to answer these and other questions.

Understanding where flood losses occur and facts about the causative events are important metrics. NHWC communities may be well postured to help. To illustrate—do we really know what percentage of flood "losses" occur in mapped floodplains vs. elsewhere? NFIP statistics provide us with one metric concerning where damage claims are paid, but this statistic alone may lead us to the wrong conclusion. NHWC communities maintain detailed storm and flood records that should help provide better answers.

NHWC communities also represent some of the largest and fastest growing metropolitan areas in the United States. Many of these communities have experienced flood disasters since their early flood detection networks were installed. Houston is one example, having experienced the most costly urban flood disaster in our nation's history (Tropical Storm Allison, June 2001). As a target of study, NHWC communities will likely know how much rain fell over what period of time and the aerial extent of the storm. Peak water levels and flow rates can be extracted from archive data and compared with regulatory flood levels/discharges. Because data archiving is important to NHWC communities, they may also know if damages occurred to uninsured properties outside the FEMA floodplain—information that cannot be gleaned from NFIP statistics alone.

The NWS is another resource that should not be overlooked. NWS routinely collects storm data from "rare" and "unusual" events including documentation of deaths and damages. This information source will help point to NHWC communities that can provide data needed to better understand why floods cost our nation so much.

THE RESIDUAL FLOOD RISK BEHIND CALIFORNIA'S LEVEES

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In light of California's sponsorship of over 1,600 miles of Federal levees and the dependence of the State Water Project and Central Valley Project on the integrity of 1,200 miles of public and private levees in the Sacramento-San Joaquin Delta, the California Department of Water Resources proposes an aggressive examination of the adequacy of the 100-year flood standard for the National Flood Insurance Program. California DWR also proposes the feasibility of establishing a new flood hazard zone in response to the residual risk of flooding for areas currently protected by levees. DWR proposes that the boundary for the new levee flood hazard zone be the floodplain for the 0.5 percent (200-year floodplain).

In response to California levee breaks in 1986 and 1997, and the resultant lawsuits and liability exposure to the State, DWR is also proposing an aggressive floodplain-mapping program for the floodplains protected by Federal levees in the Central Valley and other critical areas throughout the State subject to flooding and rapid urbanization. This program is embodied in the State's Mapping Business Plan developed to help DWR implement FEMA's Map Modernization Program.

As a result of recent California court decisions, the State of California faces an increasing level of liability associated with the operation of the Sacramento and San Joaquin Flood Control System. In the "Areola" decision the court ruled that agencies that maintain a flood project must aggressively challenge environmental permitting constraints on their maintenance activities, or they will be held liable for flood control project failures. Monterey and Santa Cruz Counties were found liable for flood damages resulting from the 1997 floods in the Pajaro River that borders the two counties. The courts found that lack of channel maintenance exacerbated the flooding along the leveed river. The recent "Paterno" decision holds the State responsible for defects in a levee foundation that existed when local agricultural interests in the 1930's constructed the levee. The "McMahan" case filed after the 1997 levee break on the Feather River names the State as a defendant for the extensive flood damages that resulted from the levee failure. The State must develop and implement strategies to improve the Sacramento and San Joaquin Flood Control System, discourage urban development in unsafe areas and reduce its exposure to liability.

California's population is experiencing one of its fastest growth rates since the post-World War II boom. The current population is estimated to be 36.1 million and is expected to grow by 50% over the next 30 to 35 years. While the State's residents and the nation is familiar with the State's exposure to large earthquakes (Loma Prieta 1989 and Northridge 1994) and devastating urban wildfires (Oakland 1991 and San Bernardino/San Diego 2003) the potential for devastating floods does not receive the media attention nor the public funding commensurate with the risk. The premise of this paper is that the State of California needs to work closely with the U.S. Army Corps of Engineers and the Federal Emergency

Management Agency to aggressively update flood maps in high-risk flood areas protected by federal levees and debris basin dams. The same agencies should also consider development of a new flood zone for areas protected by levees that provide less than a 200-year level of protection and require mandatory flood insurance for properties in the 200-year floodplain.

In California, there are about 265,000 flood insurance policies in place. For the entire State, there are 3,942 FEMA flood insurance rate map panels and approximately 536 communities participating in the NFIP. From 1994 to 2003, California property owners filed over 20,000 flood insurance claims and received over $244 million in flood insurance payments. The 1997 California floods resulted in almost $2 billion in direct damages and $5 billion in indirect costs. Approximately 23,000 homes were significantly damaged or destroyed, 9 people died and 48 counties were declared disaster areas. Other major California floods have caused more deaths and damages (1950, 1955, 1064, 1986, 1995 and 1997). There is no question that a major flood will strike California in the future.

The California area subject to the highest flood risk is the Central Valley and the Sacramento-San Joaquin Delta. In the Central Valley, there are over 1,600 miles of Federal sponsored levees for which the State has for the most part provided assurances to the Federal government that the levees will be properly operated, maintained, repaired and reconstructed. Flooding that occurs after a levee break can be catastrophic in nature; rapidly filling the floodplain with depths that can exceed 20 feet and a flooding pattern that can quickly eliminate evacuation routes.

Sacramento Valley

Prior to the construction of levees, much of the Sacramento Valley was a giant inland marsh, frequently flooded during the wet season for months at a time. Since the 1840's, an extensive system of levees, weirs, bypass systems, and reservoirs has been constructed at first in an uncoordinated and often adversarial race to build the highest and strongest levees. After 1911, flood project development proceeded under a system-wide approach directed by the U.S. Army Corps of Engineers and maintained under the authority of the State Reclamation Board. The levees that comprise the current system are a heterogeneous mix that includes old, privately constructed levees grandfathered into the existing system, recently constructed levees, and everything in between.

The current system, primarily constructed to facilitate farming in the Central Valley, is now being called upon to protect a rapidly growing urban population. Floods in the Sacramento Valley are regional in nature and take days or weeks to develop and recede. There is a critical need in this area to expand and update floodplain maps to accurately reflect current flood risks, to inspect, assess, maintain, and rehabilitate system levees, and to invest in improved flood protection for rapidly urbanizing areas.

San Joaquin Valley

The situation is similar for the San Joaquin Valley, but with an important difference. Spring snowmelt floods, such as occurred 1983 are a far greater concern in the San Joaquin Valley because a much larger fraction of precipitation is retained as snow in the high southern Sierra Mountains and the channel capacity of the San Joaquin River system is comparatively lower as compared to the Sacramento system. Throughout the Sacramento and San Joaquin Valleys, there are over 4,000 miles of additional private levees that are not sponsored or inspected by the State r Federal government. These levees have in many cases radically changed the historical pattern of flooding and are occasionally the source of local controversy.

Sacramento-San Joaquin Delta

In the Sacramento and San Joaquin Delta there are an additional 1,100 miles of levees that protect valuable farmland and small historically agricultural based communities. Many of the Delta islands protected by these levees are below sea level and are subject to deep and rapid flooding that can occur in any month of the year. The vulnerability of the Delta islands was demonstrated by the levee failure on the Middle River in San Joaquin County which flooded the 12,000 acre Jones Tract, destroyed 200 structures, 70 residences and displaced 300 agricultural workers. The San Joaquin Office of Emergency Services estimates the total damages and recovery cost associated with the levee failure to be near $100 million. Because of the proximity of the Sacramento-San Joaquin Delta to the San Francisco Bay Area, there is increased pressure of urbanization on some Delta islands and areas adjacent to Delta islands. Protecting these new urban areas against a catastrophic levee failure will be a great challenge for local communities and for the State and federal governments who are responsible for the federally sponsored levees in the Delta.

Southern California

In Southern California, rapid development on alluvial fans and in steep unstable canyons and on the coastal plain places a large and growing population at risk of flooding, landslides, and debris flows. Large floods are infrequent, but may occur with remarkable swiftness and intensity, particularly following fires such as occurred in the fall of 2003. Sixteen people died n in a debris flow laden flood on Christmas Eve 2003 in Devore and Waterman Canyon. During the same storm event, approximately 35 debris basins in San Bernardino County were filled to capacity.

The U.S. Army Corps of Engineers provided emergency assistance to San Bernardino County to excavate the debris basins in anticipation of additional storm events. Many of the debris basins are shown as providing “100-year” flood protection to downstream communities and areas subject to urban development. FEMA, the Corps and DWR need to examine the protection provided by these debris basins factoring into account the potential for a flood event occurring concurrently with the upstream watershed being partially or totally burned

Development of an “AL” Zone

The Department of Water Resources proposes that FEMA develop a new flood hazard zone for the area protected by levees that provide less than a 0.5% (200-year) level of protection. For levee systems that are certified as providing a 1 percent (100-year) level of protection that risk of experiencing a 100-year or greater flood over the 30-year life of a home mortgage is approximately 27%. For a 50-year period the residual risk of experiencing a catastrophic flood is 40%. Considering the number of communities in the Central Valley protected by levees, the residual risk of flooding due to a levee failure is too high. For the Central Valley cities of Sacramento, West Sacramento, Stockton, Lathrop, Marysville, Merced, Yuba City, Gridley, Live Oak, Woodland and Colusa, the consequences of a levee failure are devastating. Flood losses in Sacramento could exceed $16 billion from one event. Once Sacramento area levees are certified by the Corps to provide 100-year level of protection, a large number of the

40,000 homeowners who carry flood insurance will most probably drop their policies. Policy holders in Sacramento are being encouraged to not cancel their polices once levee certification is achieved but it is unknown how many will do so.

Implementation of a new flood hazard zone for the 200-year flood event for leveed areas would mitigate for the residual flood risk for urbanized areas protected by levees and would also reduce the local community's and the State's exposure to liability from a flood event that results in a levee failure. For areas protected by a certified 100-year levee systems, the "AL" zone could represent a "preferred risk" classification with lower insurance rates as compared to areas protected by levees that do not meet the 100-year standard and are mapped into an "A" zone. If implemented, the new zone could significantly increase the number of homeowners in the national insurance pool and spread the potential damages over an expanded pool of ratepayers thus decreasing the direct disaster response outlays paid by the Federal government. Taxpayers in California and throughout the United States would benefit from implementation of this proposal.

Mapping the 200-year floodplains behind levees and re-examining the certification of hundreds of miles of levees to ensure protection against the 1 percent (100-year) flood event using current FEMA and U.S. Army Corps of Engineers standards would be a combined effort of the two Federal agencies and the Department of Water Resources. DWR is committed to work with the Corps of Engineers, FEMA and stakeholder groups to investigate the economic and technical feasibility of implementing this proposal. This proposal is consistent with 1997 California Flood Emergency Action Team Report, the Interagency Floodplain Management Review Committee "Galloway" Report, and a previous study by the National Academy of Sciences on the residual risk of flooding along levee systems in the United States.

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THE NATION'S LEVEES AND THE FEMA MAP MODERNIZATION PROGRAM: THE COMING CHALLENGE FOR NATIONAL RISK MANAGEMENT

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This paper explores the interaction between the nations' "built" flood damage reduction systems and the FEMA Map Modernization Program. Historically, man has attempted to confine floodwaters by constructing levees, floodwalls and other structural measures. Approximately 15,000 miles of both Federally and non-Federally constructed levees exist in this country, many certified to provide FEMA base flood protection - allowing communities to avoid flood insurance program requirements. However, many of the analyses used to certify these levees are based on obsolete data and the true flood risk is likely understated. The FEMA Map Modernization program promises to better define the nation's flood risk. In doing so it will generate an opportunity to reassess the level of flood damage reduction provided by levees and other structures. Communities previously thought immune to flooding by the 1% chance event will now find themselves under flood insurance restrictions. Congress and the public they represent will rightly expect FEMA, USACE and other stakeholders to engage in a National floodplain management initiative to assure a common Federal approach to Flood Risk Management based on this new data. Can the Corps and FEMA work together to proactively identify communities at risk and assist the States and communities in developing flood risk reduction solutions? What impact does the aging of Flood Damage Reduction Infrastructure have on increasing flood risks? What should the Federal Government be doing overall at the National level to address changing flood risk? How can the Flood Risk Education Alliance (FREA) assist in this process?

PLANNING AND THE 100-YEAR FLOOD STANDARD

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American Planning Association

Background on APA -- The American Planning Association (APA) and its professional institute, the American Institute of Certified Planners, are dedicated to advancing the art, science, and profession of planning -- physical, economic, and social -- at the local, regional, state, and national levels. APA's 34,000 members include professional planners working in the public, private, and non-profit sectors, university teachers and researchers, individuals appointed to serve on planning commissions, elected officials, and leaders in the development and conservation communities.

APA Policies – Each year, APA's Legislation and Policy Committee recommends to the Association's Board of Directors legislative priorities for organizational and individual advocacy at federal and state levels. In addition, the Committee drafts policies for adoption by the Board on a wide variety of critical issues addressed by the field of planning. These drafts are available for review and comment by the general public as well as APA members. A "Delegate Assembly" of APA's chapters approves a final draft for submission to the Board. Approved and adopted policies are posted on APA's web site (http://www.planning.org/policyguides/) and made available to legislators, their staff, and other advocacy groups.

APA Policy on Water Resources Management -- Ratified by APA's Board of Directors in April 2002, this policy guide provides a framework for any discussion of flood policy and floodplain management issues. In general, the guide advocates for better integration of water resource issues into the comprehensive land use process. While focusing on pollution and water quality, stormwater management should be expanded to include water quantity and flooding issues.

Among 12 specific policies, Policy #1 calls for "legislation and funding to establish state comprehensive water resource and supply planning" conducted cooperatively by a number of agencies and within the context of comprehensive state planning. In addition to addressing other issues, such a state plan should have "a stormwater and flood plain management element addressing the on-site prevention, retention and treatment of stormwater runoff."

Policy #6 addresses the critical issue of stormwater management more directly: "The American Planning Association and its Chapters support legislative action and policy to manage stormwater runoff and its attendant water pollution risks by encouraging appropriate land uses in areas of sensitive water resources, and supporting the establishment of local development standards that incorporate better site design and best management practices for managing impacts on surface- and ground-water resources."

APA Research on Floodplain Issues -- In addition to its policy positions relating to stormwater and floodplain management, APA's Research Department has published several studies pertaining to these issues. Among these are:

- *Subdivision Design in Flood Hazard Areas* (PAS Report 473)
- *Planning for Post-Disaster Recovery and Reconstruction* (PAS Report 483/484)
- *The Growing Smart Legislative Guidebook*

Commissioned by FEMA, both Planning Advisory Service (PAS) reports explain current federal policy and the provisions of the National Flood Insurance Program, then describe tools and techniques planners can use to help their communities achieve – and perhaps even go beyond – the minimum federal requirements. PAS Report 473, for example, recommends that local governments base their floodplain management regulations on an adopted comprehensive plan for the community's growth. In addition to adopting zoning and subdivision regulations consistent with the adopted plan, communities can use an array of other land planning and conservation techniques to prevent or reduce flood damages in affected areas.

Among these tools are cluster development (open space subdivision design), density transfers, credits, and bonuses, planned unit development, open space requirements, greenways, buffers, and setbacks, overlay districts, performance zoning, transferable development rights, and low-density zoning. The study describes each technique in detail and provides examples from around the country. The report's appendix includes sample ordinances and development policies.

Revising the 1% Rule – APA has no formally adopted position on the possible revision of the current 1% rule. Preliminary discussions with knowledgeable members and staff reveal concerns that such a proposal may divert needed attention away from modernizing and improving the performance of state and local stormwater/floodplain planning and management – under current requirements.

While approximately one third of all flood losses occur outside the floodplain boundaries established by FEMA, other means can be found to encourage local governments and the development community to address these additional needs without resorting to a uniform, mandatory imposition of a .5%, .2% or other new rule.

Alternate Courses of Action

1) Better topographic data – Although the public at large may not be aware, there is consensus within the planning, engineering, and emergency management communities that many of the floodplain maps used in past decades were based on a rather crude understanding of topography. With better topographic data and mapping capability (GIS), it is now possible to produce much more accurate maps. APA therefore supports the effort by FEMA to upgrade the quality of all flood maps. In urban, suburban, and rural areas alike, this process will clarify realistic flood plain boundaries, still using the 1% rule.

2) Better flood data - Existing flood maps vary greatly in the quality of the flood data. Riverine flood sources, currently identified as "approximate flood zones" need to be analyzed to establish flood elevations and more accurate flood boundaries. Even those flood sources for which detailed studies have been done in the past may need to be re-evaluated for accuracy and updated using current methods. Similarly, coastal flood hazard areas should be evaluated using the latest standards and, if necessary, restudied and remapped to reflect erosion and other topographic changes.

3) Multiple benefits of digitization – The newer flood maps are produced digitally so that planners at the local level can use the flood data in conjunction with their own GIS data to clearly identify flood prone locations. This makes managing floodplain development easier at the local level because locations are readily identified on geographic information systems showing roads and even parcel lines. This will also make it possible for local planners to regulate development on land that is below the base flood elevation yet beyond the FEMA designated flood plain. More effective marrying of digital flood and land use data will also enable communities to undertake more sophisticated and comprehensive build-out analysis, such as described below. APA therefore supports the effort by FEMA to produce digital flood maps.

4) Going beyond the minimum – Government agencies at all levels, as well as national and state professional and civic associations, should join forces to educate elected officials, developers, and the public at large about the multiple benefits individual property owners and communities will derive from going beyond the minimum requirements of the NFIP. Citizens and their elected officials need to understand that the probability of a 1% flood and the baseline water level that would result can both be substantially increased depending on land development well beyond the official flood plain boundaries.

   Too often educational efforts, as well as policies and programs, have separated issues of water quality from issues of quantity. Instead, all people concerned with the health, safety, and general welfare of the community – and the ecosystem of which it is a part – should understand the linkage between these issues, such as the detrimental role played by increasing amounts of impervious ground cover (buildings, parking lots, streets) within a community. Stormwater running off such surfaces not only pollutes an area's water resources but can also dramatically affect the quantity, intensity, and direction of floodwaters.

   More widespread understanding of these issues will lead to greater support for local government initiatives that go beyond the NFIP minimums, such as establishing higher "freeboard" building requirements for structures within the floodplain. Communities taking this approach should also consider requiring additional freeboard in areas beyond the FEMA mapped floodplain boundaries if it is determined that those areas are also subject to flooding.

   Ideally, local governments should be encouraged to undertake build-out analyses so that they can determine the range of impacts if all parcels were developed to the extent allowed under current zoning and subdivision regulations. Every community will benefit from using updated and digitized flood plain maps, but if the data upon which the maps are based only reflect current development, it is like using a telescope half covered over with black tape. Neither elected officials nor the public at large will be able to envision what the community will look like – and function – at buildout. Without additional resources or technical assistance, however, many local governments serving urbanizing areas will be unable to conduct such build-out analyses and to benefit from the more precise knowledge of potential flood risks.

4) Regional cooperation and coordination – As with so many other dynamic factors influencing the quality of life in America's communities – environmental forces, transportation and housing patterns, business location decisions -- issues of water quality and quantity are no respecters of jurisdictional boundaries. However farsighted, proactive, and innovative a given community may be in evaluating its water resource issues and in taking steps to protect its supplies, encourage responsible consumption, and safeguard lives and properties from eventual floods, its efforts may be undermined by land use development decisions made far upstream.

   Just as engineers approach mapping of flood hazards on a river basin basis, floodplain management may also be conducted at a regional, rather than a merely local, level. Much more attention needs to be given to educating elected officials and the public at large on the benefits of regional coordination for flood plain management and to enabling such cooperation through statutory reform at the state level, as necessary, and the provision of additional resources and technical assistance. Such an emphasis, over time, will result in more comprehensive planning and management and in wiser investments of public funds.

BUILDING STANDARDS AND THE 1% ANNUAL CHANCE FLOOD STANDARD

Christopher Jones
Christopher Jones and Associates

Is the 1% annual chance flood the appropriate regulatory flood level for building design and construction? What are the consequences of using building standards that are tied to the 1% annual chance flood? If the regulatory flood is changed from the 1% annual chance flood, what should it be changed to? These are questions that should be addressed if the efficacy of the 1% annual chance flood is to be determined, and if an alternate is proposed. This paper will summarize recent work aimed at answering these questions.

Is the 1% Annual Chance Flood Appropriate for Design and Construction?

There are several ways to approach the question. First, the 1% value used for flood-resistant design and construction purposes can be compared against the values used in the design process against other hazards. A review of the loads standard referenced by model building codes (ASCE-7, *Minimum Design Loads for Buildings and Other Structures*) shows that other environmental conditions (e.g., wind, snow, earthquake) are mapped at various levels between 2% (50-year) and 0.2% (500-year), and calculated loads are factored (increased) to achieve designs that will not reach their limit state until the 0.02% event. Flood loads, too, are handled in the same way by ASCE-7. However, one of the primary aspects of flood-resistant design – lowest floor elevation – is maintained at the 1% level, even though structural calculations are tied to the 0.2% level (where the load factor = 1.0).

Another way to approach the question is to calculate the costs and benefits of constructing to a different flood level than the 1% flood. A project is currently underway to do just this, as part of the NFIP Evaluation. That project will be complete during summer 2004 and available for presentation at the Forum. Preliminary results for A zones, coastal A zones and V zones show the added costs of constructing low-rise residential buildings with lowest floor elevations above the 1% level are nominal. Damages (and other flood-related costs) avoided by increasing the lowest floor elevation can be significant.

What are the consequences of using building standards tied to the 1% flood?

If we look under the hood, so to speak, we may find the intended level of protection afforded by a design to resist the 1% flood is not really 1%:

- If the identification of the SFHA is incorrect, then either we fail to require flood-resistant building standards where they are needed, or we require such standards where they may not be needed.

- If the BFE determination is incorrect, then new construction may be "over-" or "under-designed" relative to the established standard.

- If the BFE determination is "correct" but subject to considerable variation or uncertainty about the mean level (a BFE represents the mean value of the 1% flood elevation), then new construction may sustain significant damage during the base flood, even though the BFE is correct and the structure complies with NFIP minimum requirements.

- If conditions change in the future, then previously constructed compliant buildings may find themselves elevated lower than future 1% flood levels.

If not the 1% Annual Chance Flood, what then?

Economic analyses (such as those in the current NFIP Evaluation Project) can provide estimates of flood frequencies where benefits of modifying NFIP minimum building standards exceed the costs of doing so.

Another way to estimate an alternate to the 1% flood standard is to infer a level of protection afforded by freeboard requirements mandated by communities. Many communities have elected to require freeboard above the BFEs shown on the flood hazard maps, either as a way to protect against floods more severe than the 1% flood, or as a way of compensating for some of the errors and uncertainty associated with the flood hazard maps. Communities usually add freeboard in even foot increments (usually one foot or two), and may not associate a particular flood frequency with the freeboard elevation. However, freeboard, in effect, provides a factor of safety and raises the flood return period against which a building is protected. The impact of freeboard can be quantified using flood elevation-frequency relationships (e.g., developed for the HAZUS coastal flood model, or from riverine flood-frequency relationships), and the level of protection achieved by many communities can, therefore, be inferred.

ARE NATURAL AND BENEFICIAL FUNCTIONS OF FLOODPLAINS BEING AFFECTED BY THE 1% CHANCE FLOOD STANDARD?

David Conrad
National Wildlife Federation

In initiating the NFIP, Congress enumerated several key purposes in the National Flood Insurance Act of 1968. Among the purposes included in Section 1302 of the Act were: "2) guide the development of proposed future construction, where practicable, away from locations which are threatened by flood hazards," "4) assure that any Federal assistance provided under the program will be related closely to all flood-related programs and activities of the Federal government," and "5) authorize continuing studies of flood hazards in order to provide for a constant reappraisal of the flood insurance program and its effect on land use requirements." In addition, Section 1302(c) of the Act directed that: "The objectives of a flood insurance program should be integrally related to a unified national program for floodplain management and . . . the President should transmit to Congress for its consideration any further proposals necessary for such a unified program, including proposals for the allocation of costs among beneficiaries of flood protection." The Unified National Program (UNP) reports were prepared and filed in 1976, 1979, 1986 and 1994, and in successive revisions the UNP increasingly emphasized the importance of protecting natural and beneficial functions of floodplains (or "the natural resources of floodplains") through the NFIP and other programs. Today, the UNP expresses an overarching national policy for management of floodprone lands in terms of co-equal purposes: ***to reduce the loss of life, the disruption, and the damages caused by floods; and to preserve and restore the natural resources of the Nation's floodplains***. (UNP, 1994)

The 1% flood standard has been part of the NFIP since its inception; however, at best it could be argued that the 1% standard is neutral towards natural and beneficial functions, and at worst the 1% standard is promoting the demise of these values. It is neutral because through the floodplain mapping process certain natural and beneficial functions are contained within the mapped floodplain. It is adverse because the floodplain management practices of the NFIP and especially the map revision process indirectly encourage the channeling of the floodplain with little regard for these values. In particular, the NFIP's allowing of encroachment on the regulatory floodway based upon a 1-foot rise standard, along with the extensive use of FEMA's Letters of Map Revision (LOMR's), in combination result in substantial floodplain development and accompanying changes in critical hydrologic and geomorphologic function of the floodplain. These changes, when combined with major habitat alterations due to water resources development, pollution from a variety of sources, introduction and spread of invasive species, and other environmental alterations are making achievement of the preservation and restoration goals more and more difficult.

Today's NFIP, with its almost exclusive focus on managing flood losses associated with a 1-percent chance flood, means that little or no attention is paid to the impacts of more frequent flood events that can be the most critical to natural and beneficial functions. Attention to more frequent flood events is necessary for the protection and management of ecosystem functions that define riverine and coastal geomorphology and the related biological functions of waterways.

To reverse this trend two key changes in management approach appear necessary. The first is adopting something closer to a zero or no-rise floodway standard as many communities and some states have already done, which would provide greater incentives to manage waterways for the benefits of their natural resources functions. To protect the natural channel, prior to approving channelizations or other hydro-modifications, it is necessary to look at the more frequent channel forming events, fully considering the hydrological, geomorphological and critical environmental effects of proposed changes on waterway ecology and geomorphologic function.

The need for such changes is becoming increasingly evident. Our long term use of flood control and poor watershed management practices has led to signficant environmental calamities that are now being corrected at a significant societal cost. We are currently witnessing initial estimates of more than $8 billion to restore health to south Florida's Everglades, more than $14 billion to staunch the massive erosion and degradation of Coastal Louisiana's wetlands and declining fisheries, more than $5 billion to reverse the decline of the Upper Mississippi's wetlands, fisheries, and wildlife habitat – all of which have been subject to degradation from large scale flood control and navigation alterations, as well as degradation of tributary floodplain functions. These are only just beginning to point to even larger potential future costs required to address degraded environments. The point being that while the NFIP was not necessarily responsible for these specific calamities, concurrently the NFIP's LOMR process has been repeating these failures on a micro-scale in thousands of communities across the nation.

Another example that perhaps has a more direct interface with the NFIP is efforts to restore the Chesapeake Bay (at a projected cost of $18 Billion by 2010). One of the strategies employed with the Bay cleanup is local standards that require substantial development setbacks from the Bay and from Bay tributaries located many miles upstream from the Bay to control sediment and the pollutants entering the Bay. Not only do these practices support the Bay program objectives, but these practices enhance flood protection by further encouraging setbacks. Nevertheless, implementation of these standards is hampered by the weaker standards of the NFIP, since many argue that the NFIP standards should be sufficient.

Another example of a program that has enhanced both the flood protection benefits and the protection of natural and beneficial functions would be the Clean Water Act's Section 404 dredge and fill permitting program. Most notably in the western United States, the 404 program is applied almost exclusively to riparian zones that function like wetlands. In areas such as Central and Southern Arizona this has led to many planned developments incorporating the riparian resources rather than obliterating these resources.

In conclusion the next changes to the NFIP flood standard should include the following:

1. Conservation of natural storage should be considered when establishing floodway mapping and management practices.

2. As part of our floodplain mapping initiatives we should attempt to inventory the natural and beneficial functions within the floodplain.

3. LOMR's should be based on more than evaluating the 1-percent chance flood standard. Fluvial geomorphologic principals should be considered when considering channel change.

4. The NFIP must be tied to the broader watershed, considering both stormwater and water quality concerns.

HOW THE 1% STANDARD RELATES TO PROTECTION OF NATURAL AND BENEFICIAL FUNCTIONS OF FLOODPLAINS

Chad Berginnis
Association of State Floodplain Managers

To maximize the protection of the natural and beneficial functions of floodplains, the use of the 1% standard is somewhat of an anomaly. In a physical sense, the 1% standard does not correlate to a specific type of riparian zone. Nor does a 1% chance floodplain reasonably correspond to a particular type of ecosystem. There is no such thing as a 1% meander zone in geomorphologic terms. Instead, the 1% standard was developed as a policy construct to abate economic losses due to flooding balanced with publicly acceptable land use regulations. A standard that initially focused on damage and loss reduction, the 1% standard is now being utilized to also protect natural and beneficial functions of floodplains. This is being accomplished by:

1. Being adopted and implemented as a national standard as a result of the National Flood Insurance Program (NFIP), especially the utility of the "floodway" concept.
2. Being adapted by the federal government to provide natural benefit protection through programs like the Community Rating System and, in theory, the identification of Coastal Barrier Resource Areas.
3. Using the default national standard as a backdrop, communities and states adapting the 1% standard to manage floodplains as a natural resource.

Emergence of the Natural Benefit in Federal Policy

In the 1950's and 1960's, just before the era of non-structural floodplain management emerged, national experts focused their efforts on finding alternative approaches to managing nation's rising flood losses. Decades of investment in flood control works as a sole solution was determined to be insufficient. These experts focused on damage avoidance, preserving areas to allow for the efficient flow of flood waters and balancing structural and non-structural approaches to floodplain management. The culmination of this national discussion was the 1966 Unified National Program for Managing Flood Losses which recognized the need for a unified approach to floodplain management. In subsequent years, the passage of the National Flood Insurance Act, the National Environmental Policy Act, Clean Water Act, and the issuance of Executive Orders 11988 -- Floodplain Management and 11990 – Protection of Wetlands, necessitated the revision of the Unified National Program document. The 1979 revision incorporated the federal concern with "natural and beneficial values" of floodplains and expanded the strategies, tools and conceptual framework of floodplain management accordingly.

1% Standard Established Nationally as a Result of the National Flood Insurance Act

The importance of the National Flood Insurance Act cannot be overstated in terms of establishing a national standard for the identification and regulation of flood hazard areas. In particular, rules that resulted in the establishment of the concept of a regulatory floodway, introduced many communities across America with the notion of keeping a flow conveyance area largely free of obstruction and development so floodwaters can be adequately passed downstream. Even this standard is solely focused on flow conveyance – protection of natural functions is merely a secondary benefit. Still, the floodway rules have provided some protection to riparian zones, aquatic ecosystems, and wildlife migration corridors, in over 9,000 square miles of identified floodway areas.

There remain opportunities for improvement that would result in both better reduction of flood losses and preservation of natural floodplain functions. Some problems with existing regulations include the concept of the floodway based on a 1foot rise (minimum national standard), the issuance of map changes for floodway encroachments, and lack of clear guidance on no-rise floodway encroachment analyses, and the absence of standards for fill.

Federal Government Adapting the 1% Standard for Managing Natural Functions
In the past 30 years, there have been new programs developed to enhance the management of natural floodplain functions and synergies created by aligning other programs with the NFIP. The Coastal Barrier Resources Act (CBRA) was enacted in 1982 to protect barriers islands from development. The act does not allow federal money to be used in the development and/or redevelopment of barrier islands, including the disallowance of the purchase of flood insurance through the NFIP for new and substantially improved structures. Although delineated CBRA areas cover an estimated 3 million acres, the Act falls short of putting a moratorium on growth on barrier islands, since private resources can still be used to fund development in these areas, and allows pre-Act constructed structures to remain eligible for flood insurance through the NFIP.

Secondly, the NFIP's Community Rating System (CRS). was implemented in 1990 as a program for recognizing and encouraging community floodplain management activities that exceed the minimum NFIP standards. The CRS is structured to provide credit for activities that protect and enhance natural and beneficial values of floodplains.

Communities and States Adapting the 1% Chance Standard for Managing Natural Functions
Perhaps the greatest contribution that the 1% chance standard has had on natural benefit protection is that through the NFIP, a **federal backdrop** for regulating such flood hazards has been created. This backdrop, through the establishment of nationwide minimum standards, results in a more solid legal and political footing for states and communities to regulate for natural benefit protection as well as flood loss reduction. For example, some states have near zero-rise floodways that result in much of the floodplain being identified as floodway area. Others have introduced the concept of prohibited uses in floodplain areas. Communities throughout the nation have adopted standards that prohibit habitable structures, provide for compensatory flood storage, require floodplain restoration, mandate setbacks, and allow no adverse impacts on flood velocities and/or sedimentation. In the absence of such a federal backdrop, in the forms of programs and regulations, it can be argued that state and community efforts to protect natural benefits would be significantly impacted. Such is the commentary that many states provided to the Environmental Protection Agency in 2003 in response to the Advance Notice of Proposed Rulemaking on the migratory bird rule and reducing federal jurisdiction over isolated wetlands.

Overall, there are a number of unresolved issues that, if addressed, would result in better protection of the natural and beneficial functions of the floodplain:

1. *Establishment of a Unified National Program for Floodplain Management*. Reports and a framework have been prepared for nearly thirty years, yet we still lack any clear national policy guidance for floodplain management – especially for the consideration of natural and beneficial functions of floodplains. Since the Unified National Program document has increasingly emphasized natural benefits of floodplains, unambiguous guidance must be developed and implemented.

2. *Development of data identifying where the intersection of the 1% chance floodplain and quantifiable natural resources intersect*. What percentage of wetlands are in the 1% chance floodplain? How many acres of prime farmland are in the 1% chance floodplain? Where are the sole source aquifers in 1% chance floodplains? What watercourses have both detailed flood studies and TMDLs developed? By developing this data, program managers and policy makers can more strongly link protecting natural functions of floodplains and existing programs.

3. *Updating/Clarifying the NFIP*. Could this program be made to better protect natural floodplain resources and reduce flood damages? In the Findings section of the original Act, Congress stated it is the purpose of this title to "guide the development of proposed future construction away from locations which are threatened by flood hazards." Current rules do not fulfill this intent. Also, even after existing for more than 30 years, many flood hazard areas are not identified. Better mapping will ultimately result in better resource protection.

DEFINITION OF A NATURAL—VERSUS REGULATORY—FLOODWAY TO PROTECT BENEFICIAL FLOODPLAIN FUNCTIONS

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Introduction

A significant natural function of river floodplains is to provide storage and conveyance of flood flows. The predominant consideration of floodplain function has historically been for conveyance only, as exemplified in the provisions of the National Flood Insurance Program (NFIP) that focus on regulating new development with respect to the one-percent-annual-chance, or base flood, condition. At this extreme flow condition, natural river floodplains tend to behave as conveyance channels only. However, during more frequent flood events, when shallower floodwater depths occur, the floodplain tends to behave more like a storage reservoir. It is these more frequent flood events that also have a greater effect on shaping the morphology of the river channel as well as riparian fish and wildlife habitats.

FEMA established the regulatory floodway as a floodplain management technique that would allow the development of floodprone areas while limiting increases of future flood hazards. It is defined as "the channel of a river…and adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height." The regulatory floodway concept does not directly acknowledge or protect the beneficial natural functions of floodplains—the *natural floodway* concept is intended to do this.

Floodplain Functions

As water overflows the banks of a river, water velocities entering the floodplain tend to slow due to resistance from vegetation and topography. This ability of the floodplain to slow the mass of water moving down a river causes a reduction in the velocity of the flow in the main channel also. Bhowmik and Demissie (1982) found that floodplains may act as storage reservoirs for low return period flood events—less than the 40-year event—because the floodplain and main channel tend to act as separate flow systems. For greater flood events, the channel-floodplain systems tend to act as one unit for flow conveyance.

Bhowmik and Demissie (1982) also investigated the relationship between average flow velocity in the river channel and floodplain with increasing depth of flow. Figure 1 provides depth and velocity findings for a natural river channel and floodplain system. It can be seen that as a river overflows its banks onto the floodplain, there is a tendency for the average velocity of the total flow—and the main channel flow itself—to decrease. This decrease of the main channel velocity is believed to be induced by the slowing of the mass of water on the floodplain. The average channel velocities begin to increase again after reaching a minimum value as the flow and depth increases on the floodplain. Laboratory experiments and field observations indicate minimum velocities, or maximum thresholds of flow attenuation and storage, tend to occur when the average depth of water in the floodplain is between 30 and 40 percent of the average depth in the channel. Similarly, Anderson *et al* (1999) related the interaction between the stream and its floodplain to a "relative depth" parameter (H-h)/H, where (h) is the fixed channel bankfull flow depth, (H) is the higher elevation, variable channel flood depth, and (H-h) is the resulting floodplain flow depth. Maximum floodplain storage was observed to occur at relative depths of 0.10 to 0.30, typically at 0.20. Conversion of these relative depths, and average depths from Bhowmik and Demissie (1982), result in flood/bankfull flow depth ratios from 1.25 to 1.7, with an average value of 1.5.

Relationships between regional ratios of flood/bankfull flow depths and flood event return periods have been compiled by Leopold (1994). A comparison of the flow depth ratios described above to these regional values indicates maximum floodplain storage may be achieved for rivers in the Western Cascades and Puget Lowland regions between the 5-year and 50-year flood events, with the average ratio of 1.5 generally corresponding to the 10-year flood.

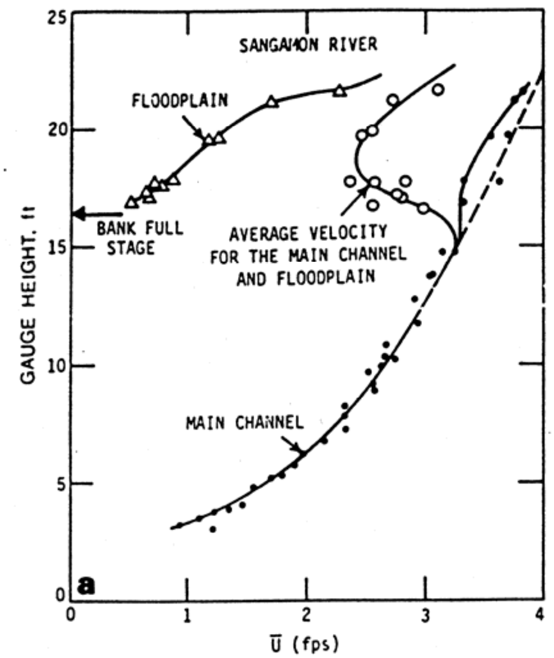

Figure 1. Variation of Average Velocity with Depth in a Natural Channel-Floodplain System (Bhowmik and Demissie, 1982)

Conclusions and Future Work

Delineation of a "natural" floodway is intended to augment the established FEMA regulatory floodway and preserve the natural function of a floodplain to store floodwaters and reduce the average velocity of streamflow during frequent flood events. Initial investigations, begun by the author four years ago, have indicated the natural floodway may generally correspond to the 10-year floodplain for rivers in the Pacific Northwest. Preservation of this portion of the 1% annual chance floodplain would therefore help reduce the risk of riparian and in-channel habitat disturbances, as well as reduce flood risks to human infrastructure.

Future work is intended to address the biological functions of floodplains, such as those characterized by the flood pulse concept (Junk *et al*, 1989). It is anticipated that ecological processes will need to be better recognized within the NFIP to be responsive to allegations of Endangered Species Act violations, as typified by a recent lawsuit against FEMA in Washington State (Hasselman, 2003).

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HOW DOES THE ONE-PERCENT STANDARD AFFECT FEDERAL HIGHWAY ADMINISTRATION PROGRAMS? WHAT MIGHT CHANGES IN THE STANDARD MEAN?

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Introduction

There are approximately 500,000 bridges in our Nation's Highway System that cross nearly every kind of waterway imaginable. These bridges are found on the Interstate system, local roads, highly urbanized areas, and in some of the most environmentally sensitive and scenic areas in the country. In addition, the structures themselves are built out of many different types of materials and can be found in every conceivable configuration. The challenge that engineers, planners, and environmentalists face is to build cost effective structures that are safe for the traveling public, cause minimal impact on the environment, and are economically feasible. Often times, these goals are at odds with one another.

Background

Floodplain policy and regulations governing Federal-aid highway projects, developed by the Federal Highway Administration (FHWA), are contained in:

Title 23 of the Code of Federal Regulations (23 CFR) – Highways,
Chapter I – Federal Highway Administration, Department of Transportation,
Part 650 – Bridges, Structures, and Hydraulics,
Subpart A - Location and Hydraulic Design of Encroachments on Flood Plains.

The purpose of the 23 CFR 650 Subpart A is to prescribe FHWA policies and procedures for the location and hydraulic design of encroachments of Federal-aid highway projects onto flood plains, including highway projects designed and constructed on Federal Lands. It is the policy of the FHWA:

- To encourage a broad and unified effort to prevent uneconomic, hazardous or incompatible use and development of the Nation's flood plains,
- To avoid longitudinal encroachments, where practicable,
- To avoid significant encroachments, where practicable,
- To minimize impacts of highway agency actions which adversely affect base flood plains,
- To restore and preserve the natural and beneficial flood plain values that are adversely impacted by highway agency actions,
- To avoid support of incompatible flood-plain development,
- To be consistent with the intent of the Standards and Criteria of the National Flood Insurance Program, where appropriate, and
- To incorporate "A Unified National Program for Floodplain Management" of the Water Resources Council into FHWA procedures.

Other significant elements outlined in 23 CFR 650 Subpart A are definitions, applicability, public involvement, location hydraulic studies, only practicable alternative finding, design standards, and content of design studies.

Use of One-Percent Standard in Federal-Aid Highway Projects

The one-percent standard (the flood that is expected to occur one time in 100 years) is used in FHWA flood plain policy to define the base flood and base flood plain, which are defined as the flood or tide having a one-percent chance of being exceeded in any given year and the area subjected to flooding by the base flood, respectively. The design flood is defined as the peak discharge, volume if appropriate, stage, or wave crest elevation of the flood associated with the "probability of exceedance" selected for the design of a highway encroachment. The highway is not to be inundated from that stage of the design flood. The intent of the policy and guidance is to establish the design flood based on the results of an economic analysis that attempts to weigh the costs associated with assuming risk against costs associated with structural factors. Evaluation of risk includes costs associated with minimizing flooded areas, detour lengths, time to reopen, critical route destinations, route use, frequency of use, and other factors. Structural factors include bridge length, width, and substructure type and configuration. Determination of design floods using these procedures are problematic due to the difficulty in accurately determining the costs associated with risk. Because of this, most Federal, State departments of transportation (DOTs), counties, cities, and other bridge owners resort to design floods based on policy. The policy is usually based on quantitative factors such as average daily traffic and road classification. Other qualitative factors that can influence the selection of the design flood are environmental impacts, flooded areas, detour lengths, time to reopen, critical route destinations, and route use.

Determining bridge lengths using the one-percent standard also significantly impacts FHWA's bridge scour program. Guidance for selection of the design flood for the evaluation of scour at bridges (new and existing) is contained in FHWA's Technical Advisory 5140.23 – "Evaluating Scour at Bridges," and in Hydraulic Engineering Circular Number 18 – "Evaluating Scour at Bridges – Fourth Edition." The publications provide policy and guidance on the recurrence intervals to use for evaluating scour at bridges. Current guidance is to design the foundation of bridges to withstand the effects of scour without failing for the worst conditions resulting from floods equal to or less than the one-percent flood. A further criterion is that foundations should be checked to ensure that they will not fail due to scour for the two-tenths of one-percent flood (the flood that is expected to occur one time in 500 years).

Impact of Changes on the One-Percent Standard

If a more conservative approach is taken towards establishing design events (reducing frequency of occurrence of design flood event), longer and more expensive bridges would result. However, since the magnitude of scour that occurs at a bridge foundation is a function of depth and velocity of flow longer bridges could result in reduced foundation costs. A less conservative approach (increasing frequency of occurrence of design flood event) could result in shorter and less expensive bridges. However, flow depths and velocities could increase which would result in greater scour depths and increased foundation costs.

Other problems can result in changing the one-percent standard. In some situations, replacing an existing bridge with a longer structure can result in increased downstream flooding due to the lack of flood peak attenuation. Recently, several State DOTs have lost very expensive lawsuits that resulted from claims made by downstream claimants.

Challenges

The one-percent standard is applied through the use of a variety of hydrologic and hydraulic techniques. The engineering community should be challenged to use the best possible tools available to them when determining design floods, and establishing flooded areas. Better hydrologic and hydraulic tools are available than are routinely applied in daily practice. Hydrologic models are available that more accurately develop hydrologic estimates and hydraulic models are available that more adequately evaluate flow patterns in flood plains and at bridges. Tools are also available to more adequately evaluate sediment movement in our rivers and streams.

The engineering community should also be challenged to develop better tools for completing the analysis. For example, in some parts of the United States the best available rainfall data is over forty years old. Studies should be undertaken to develop better estimates of rainfall frequencies and amounts. More accurate data in this area would directly lead to more accurate estimates of design floods and consequently to more accurate flood plain delineations.

Summary

Selecting the appropriate size bridge provides many challenges to the hydraulic, geotechnical, and structural engineering community. Determining the appropriate design event is a delicate balancing act that must satisfy the needs of many interested parties. The length of the bridge must be evaluated with consideration of flooded areas. Clearance of the bridge over the water surface at flood stage must consider the effects of debris, ice, and approach roadway geometry and the cost of the superstructure and substructure must be evaluated considering the effects of scour at the bridge foundation. And perhaps above all else, the bridge must be safe for the traveling public and must provide minimal impacts in sensitive environments.

NRCS PERSPECTIVES ON THE 100-YEAR FLOOD STANDARD

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Primary NRCS Programs for Flood Mitigation

- Watershed Protection and Flood Prevention Program –PL-83-566
- Floodplain Easements-Emergency Watershed Protection Program-PL-81-516

Watershed Protection and Flood Prevention Program

While the target standard for flood protection is to treat and provide flood protection to the 100-year level, there is nothing in statute or regulation that requires, nor limits the maximum level of protection. Each project addresses the significant natural resource, social and economic concerns within watershed, including flood mitigation. In every project or problem area, NRCS can utilize its full range of technical and financial assistance program tools along with any tools of other federal, state or local programs. Frequently, the Agency partners with non-profit or non-governmental groups and organizations to accomplish the natural resource goals set in a locally developed watershed project.

The Agency's philosophy and long history demonstrates a strong commitment to *deal* with the raindrop as high in the watershed as possible, and even before it strikes the land through conservation practices applied on farms and ranches. Let us not forget that irrespective of the specific flood mitigation measure, ranging from 40 acres of restored wetlands retaining 80 acre-feet, to a 1000 acre floodwater retarding structure, detaining 10,000 acre-feet; the only flood mitigation benefits are realized, downstream.

Locally Led and Driven Programs

Local communities, project sponsors, are provided assistance in installing planned land treatment measures when plans are approved. Surveys and investigations are made and detailed designs, specifications, and engineering cost estimates are prepared for project implementation. Technical assistance is also furnished to landowners and operators to accelerate planning and application of conservation measures on their individual land units.

Floodplain Easements-Emergency Watershed Protection Program

Background—Since 1996, NRCS has purchased floodplain (FP) easements on lands that qualify for EWP assistance. Floodplain easements restore, protect, maintain, and enhance the functions of the floodplain; conserve natural values including fish and wildlife habitat, water quality, flood water retention, ground water recharge, and open space; reduce long-term federal disaster assistance; and safeguard lives and property from floods, drought, and the products of erosion. NRCS may purchase FP easements on any floodplain lands that have been impaired within the last 12 months or that have a history of repeated flooding (i.e., flooded at least two times during the past 10 years). Purchases are based upon established priorities.

Payments and Restoration**—**A landowner voluntarily offers to sell to the NRCS a permanent conservation easement that provides the NRCS with the full authority to restore and enhance the floodplain's functions and values. The easement provides NRCS with the authority to restore and enhance the floodplain's functions and values. NRCS may pay up to 100% of the restoration costs. To the extent practicable, NRCS actively restores the natural features and characteristics of the floodplain through re-creating the topographic diversity, increasing the duration of inundation and saturation, and providing for the re-establishment of native vegetation. The landowner is provided the opportunity to participate in the restoration efforts.

More information:
http://www.nrcs.usda.gov/
http://www.nrcs.usda.gov/programs/watershed/
http://www.nrcs.usda.gov/programs/ewp/floodplain_ewp.html#Program%20Signup%20Information

NRCS HYDROLOGY TOOLS

The Natural Resources Conservation Service (NRCS) released its first official hydrology guidance titled "Hydrology Guide for Use in Watershed Planning, November 1954. This important technical agency reference has now evolved into several documents including the National Engineering Handbook, Part 630, Hydrology. All of the current chapters of this document are available at this website http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models.html.

In general NRCS hydrology techniques equip our engineers and hydrologists and partners to choose the most suitable hydrologic method to use for a given problem. This can range from simple analysis on a very small drainage to a complex hydrologic analysis of a project costing millions of dollars. Very often there is little climate and gauged run-off data available. The chosen method in each case must be adequate to arrive at sound conclusions in terms of physical and climatic conditions, objectives, hazards, criteria specified by the sponsors or funding sources and functions of the project. NRCS provides modeling tools and technical support for utilization of the agency technology and centralized resource information. The following paragraphs will briefly describe some of these technical support tools.

Technical Release No. 20: Computer Program for Project Formulation Hydrology (TR-20) is a physically based watershed scale runoff event model. It computes direct runoff and develops hydrographs resulting from any synthetic or natural rainstorm. Developed hydrographs are routed through stream and valley reaches as well as through reservoirs. Hydrographs are combined from tributaries with those on the main stream stem. Branching flow (diversions) and base flow can also be accommodated.

The DOS based TR-20 computer model will soon be released in an updated windows format. A Beta Test version (including programs, sample data, and documentation) is available at the above web site.

NRCS has adopted the Corps of Engineer's HEC-RAS (River Analysis System) for computation of water surface profiles. Use of the NRCS program WSP2 has been phased out as NRCS engineers become trained and experienced with HEC-RAS. The major advantages of this program are Windows-based graphics for input and output and program technical support at the Corps of Engineers Hydrologic Engineering Center, future enhancements and its wide spread use.

NRCS Hydro is an ArcView GIS interface to the WinTR-20 hydrologic model. It operates with ESRI ArcView 3.3 and the Spatial Analyst extension. The interface is organized to complete the steps required to do a WinTR-20 hydrologic analysis. Using tools and menu selections, the user is guided step by step through the automated processes of defining the watershed boundary, dividing the watershed into sub-areas, developing cross sections, etc. The end result is a WinTR-20 execution with peak discharges, hydrographs, etc.

NRCS's computer program for analyzing small watershed hydrology now called WinTR-55 has been completely rewritten. As a Windows based program, the input and editing windows are a big improvement over previous DOS versions. WinTR-55 uses the WinTR-20 program as the driving engine for more accurate analysis of the hydrology of the small watershed system being studied.

The Water Resources Sites Analysis program (SITES) is a descendent of DAMS2, a full-featured rainfall-runoff routing program developed for watershed dam design and analysis. In developing the SITES software, DAMS2 was recoded and the auxiliary (emergency) spillway analysis portion of the program was rewritten and expanded to include new technology for spillway performance evaluation.

The auxiliary spillway performance model incorporated into SITES utilizes an iterative application of a three-phase approach to the spillway erosion process. When applied in design, the earth spillway erosion model incorporated into SITES is normally used to evaluate the potential for spillway breach under a freeboard hydrograph having at least 24 hours rainfall duration. In its present form, the program is not able to evaluate the rate of breach when a breach is predicted. Evaluation of the potential for extending the model to use for predicting breach rate is presently underway.

NRCS is making considerable investments in improving these basic tools on watershed analysis through upgrading to windows formats, use of common scientific modules and common data sets for climate, soils, and other hydrologic information. They are available now through web sources for ease of access by all of our state and county level offices and partners across the U.S.

As data bases are more complete and compatible with our more powerful windows based modeling tools we are making good use of the recently released Precipitation Frequency Studies by the National Oceanic and Atmospheric Administration (NOAA). While the new NOAA Atlas 14 covers the desert southwest and NOAA Atlas 14-Volume 2 covers the Ohio drainage and associated states in the east there is still much of the U.S. relying upon precipitation frequency analyses that are very outdated and possibly not representative of the precipitation factor in watershed hydrologic analyses. This is an example of the continual advancements in this technology and the need to share resources to improve our technical capability.

IMPROVING IMPLEMENTATION OF THE 1% FLOOD STANDARD

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National Association of Flood and Stormwater Management Agencies

NAFSMA's answer to the above question is yes for three reasons. First, the 1% chance flood standard has been in place for too long to change without serious disruptions to many organizations, local and State governments, and individuals. Second, additional future flood damage reductions can be obtained without changing the 1% chance flood standard.. Third, improved enforcement of existing rules and regulations that accompany the 1% chance flood standard will yield further flood damage reduction benefits.

The 1% chance flood has been the nation's standard for actuarial and regulatory purposes for more than 30 years. The Federal Emergency Management Agency (FEMA) has published Flood Insurance Rate Maps (FIRMs) for more than 18,000 communities, all of them emphasizing the 1% chance floodplain and floodway. Most of these communities have joined the National Flood Insurance Program (NFIP) by, in part, adopting floodplain regulations geared to the 1% chance floodplain and floodway depicted on the FIRMs. Billions of dollars worth of public and private investment decisions have been made on the basis of that flood risk. The administration estimates that local government compliance with NFIP standards for new construction is avoiding over $1 billion in flood damage annually.

There are three NFIP regulations that could be modified to further reduce future flood losses. These modified regulations would be prospective and be particularly beneficial in newly developing or redeveloping areas, while keeping the 1% chance flood standard. They relate to floodways, freeboard and future conditions.

FEMA defines the floodway based on encroachment <u>into</u> the 1% chance floodplain which results in a rise in flood elevation of a maximum of one-foot. FEMA will not recognize a more restrictive standard unless it is enforceable under state statute. A reduction in the allowable rise or not allowing a rise in defining floodways would reduce future damages without changing the 1% chance flood standard.

FEMA's minimum standards for floodplain regulations do not require any freeboard for structures built <u>in</u> the 1% chance floodplain. A change in policy to require freeboard (e.g. 1-2 feet) would reduce future damages. The value of freeboard is reflected in flood insurance rates. For example, for a one floor home without a basement enclosure, $100,000 in flood insurance for the structure would cost (before fees) $530 a year for a structure built to the base flood elevation (BFE), $335 a year at BFE plus one, and $200 a year at BFE plus two.

FEMA uses hydrology based on existing watershed development conditions, even though it is well known that future development will change the hydrologic regime and increase 1% chance flood discharges. FEMA did change their regulations a few years ago to allow the future 1% chance floodplain to be shown on the FIRMs at the request of local governments, but the existing discharge is what is official. Requiring future conditions hydrology to map 1% chance floodplains would reduce future flood damages. Furthermore, using future conditions hydrology offers potential to reduce the needs and costs for continual updating of the FIRMs for the 18,000+ participating communities.

Finally, there are communities and developers who want to do the right thing; and there are communities and developers who will do whatever they can to avoid or circumvent sound floodplain management practice. Stronger enforcement of the existing rules by FEMA and a genuine commitment of the participating communities would reduce future flood losses.

While we support the 1% chance flood standard, we also advocate for supplemental actions that can further reduce future flood damages and help ensure that decisions made today will be good for tomorrow. Areas to be addressed include catastrophic levee or dam failures, channel migration outside the mapped floodplain, increased emphasis on pre- and post-disaster mitigation, and more accurate maps through an adequately funded map modernization program.

MODIFICATIONS NEEDED IN IMPLEMENTATION OF THE 1% CHANCE FLOOD STANDARD

Dennis Lawlor
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The annual flood losses in the United States have nearly tripled since 1951, to more than $6 billion (when adjusted for inflation). This trend clearly demonstrates that the current federal minimum standards for floodplain management are not adequate. Included in these standards is the 1 % chance flood, which was arrived at through compromise to appease all of the interested parties when the National Flood Insurance Program was created.

Recently, the Association of State Floodplain Mangers adopted the No Adverse Impact (NAI) strategy. This strategy strives to ensure that the actions of one property owner do not increase the flood risk of other property owners. To be effective in achieving flood loss reduction, additional minimum standards need to be applied to the 1 % chance flood and an Executive Order that fully embraces the NAI strategy needs to be issued. Additionally, a comprehensive review of the minimum standards should occur every 8 years to ensure that the standards have been effective in decreasing flood losses

Where We Have Been

Flood losses in the United States have continued to rise since the inception of the National Flood Insurance Program in 1968. This trend demonstrates that the current minimum federal standards are not reducing flood losses. The current standards have been compromised to the point that they are not effective and reducing flood losses in the future will be very difficult to achieve. Reducing flood losses on a national basis cannot be managed by evaluating isolated issues and conditions. Development occurring outside of the one percent annual chance floodplain has induced new and additional damages within the floodplain. The current regulations are not providing long-term, one percent chance flood protection for new construction.

Where We Need To Go

A cooperative, integrated effort by federal, state, and local governments and the private sector is needed to minimize flood damages in the United States, to prevent future damage, and to protect the natural resources of the nation's floodplain lands.

Effective floodplain management programs across the country have adopted higher standards that recognize local flooding conditions and local desires for heightened levels of protection and preservation of the natural resources in the floodplain.

Most states have some method of keeping track of how the communities in their jurisdiction are performing, however, it is less clear how the states utilize this information and what effort goes into examining the state programs themselves.

Effective state floodplain management programs ensure that floodplain hazard mitigation objectives are integrated into local comprehensive planning.

Approximately 90% of the states reported that their local officials are reluctant to adopt and enforce floodplains regulations to restrict development in floodprone areas. Approximately 25% of the states do not have any regulations more stringent than FEMA's minimum standards. Therefore, the minimum standards, including the application of the 1% chance flood must be reevaluated.

Policy makers must adjust the minimum standards so flood loss reduction will be achieved. The Association of State Floodplain Mangers has initiated the NAI strategy and this strategy must be incorporated into the fabric of the minimum standards.

If the 1% chance flood standard is to be maintained as the minimum standard for calculating the regulatory flood, the following conditions must also be included as minimum standards:

1) There must be a mandatory freeboard of two feet above the base flood elevation. Less than half of the states have at least one foot freeboard as part of their regulation, however more than half of the states have at least one foot freeboard recommended as part of the model ordinance. To fully account for the uncertainties in the determining the flood frequencies and flood elevations this must be increased.

2) Future conditions hydrology must be standard for all floodplain studies. Future conditions hydrology is performing the hydrology for a fully developed community. The hydrologic study is based on the community's zoning map or land-use plan. If the community does not have a zoning or land-use map then the suggested standard would be to add 25% to the Existing 100-year discharge.

3) Currently, all statistical analysis of river flows and regional analyses are performed with a 50% confidence limit applied to the estimate. This confidence limit should have greater accountability. The minimum confidence limit should be 90%.

4) New actuarial adjustments to the insurance rates of the NFIP must be mandated based on new vulnerability assessments within the 1% chance floodplain. As new comprehensive all-hazard planning initiatives are undertaken by communities, data will be available to analyze the true risk of structures located in the floodplains.

5) The current standard for floodway encroachments includes a one foot surcharge limit. This surcharge limit should be reduced to one-half foot. Approximately 35% of the states regulate the floodway or floodway fringe areas. The base flood elevations shown on a Flood Insurance Rate Map do not include elevations that reflect the one foot surcharge limits.

6) The importance of the natural and beneficial functions of floodplains should be encouraged. Environmental impacts have been ignored and are treated as separate issues in the floodplain management regulations. Additional incentives for creating buffer strips, riparian corridors, and wildlife reserves will provide good water quality benefits and help with providing storage areas for floods.

7) Development in areas below dams should be regulated to prevent the hazard classification of dams to increase from low hazard to high hazard.

These standards should be reevaluated every 8 years to ensure that flood losses are decreasing and the goals of the program are being met. The President should issue a new Executive Order on "No Adverse Impacts" to re-affirm and expand the federal government's commitment to floodplain management. The Water Resources Council should be re-established to address floodplain management policy issues.

Many of the nationwide standards for floodplain management and flood loss reduction now in use are directly derived from the minimum floodplain management requirements of the National Flood Insurance Program. Based on forty years of experience in the NFIP, the minimum standards must be adjusted so flood loss reduction can be achieved.

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WHAT DOES THE 1% FLOOD STANDARD MEAN? REVISITING THE 100-YEAR FLOOD

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The 100-year flood discharge, $Q_{0.01}$, is an elegant abstract concept that presents complications when applied to real-world problems. We recognize the importance of $Q_{0.01}$ to floodplain management and to the development and operation of the National Flood Insurance Program. Yet estimates of $Q_{0.01}$ are highly uncertain even in the best of circumstances. $Q_{0.01}$ is not directly measurable, although solid lines on flood insurance rate maps imply otherwise. In many cases $Q_{0.01}$ is not even constant. Not only do *estimates* of $Q_{0.01}$ change over time (because of random variability in the sample of floods that have been observed), but $Q_{0.01}$ *itself* varies as watersheds and channels are developed or altered and as climate changes.

This paper briefly reviews some properties of the 100-year (or 1-percent exceedance) flood and its corresponding estimators and makes some recommendations about how they might be improved. The manuscript does not directly address the wisdom of the 1-percent exceedance level -- as opposed to, say, the 2-percent or 0.5-percent exceedance level – except to note that any attempt to assert that a given discharge is the 1 percent exceedance and not the 2 percent or 0.5 percent is demanding an unrealistic level of certainty in a highly uncertain world.

Origins of the 100-Year-Flood Concept

In the 1960's the Department of Housing and Urban Development (HUD) convened a group of experts to advise the agency on the best standard to be used for risk assessment, insurance rating, and floodplain management. After extensive study and coordination with Federal and State agencies, this group recommended the 1-percent-annual-chance flood (also referred to as the 100-year flood or "base flood") be used as the standard for the National Flood Insurance Program (NFIP). The 100-year-flood standard was thought to balance an adequate level of protection without overly stringent burdens and requirements for property owners.

There are doubts about how well this balance has worked. Despite nearly $3 billion spent mapping 150,000 square miles of 1 percent floodplains and creating maps for more than 19,000 communities, U.S. flood losses continue to increase [Pielke and Downton, 2000], particularly losses outside the *designated* 1 percent floodplains. Part of this increase can be attributed to inaccurate floodplain mapping due either to errors in estimates of $Q_{0.01}$ or to errors in converting $Q_{0.01}$ to an accurate water-surface profile and ultimately to a planimetric representation of the area inundated by a flood with that discharge.

Uncertainty and Variability

Sampling Variability: Estimating $Q_{0.01}$ at a site typically involves extrapolation because data sets are almost universally less than 100 years in length and thus the sample of observed floods may not contain an event as large as $Q_{0.01}$. Figure 1 shows a typical record, 44 years of data from the Big Sandy River (TN), along with a fitted frequency curve and corresponding 95-percent confidence intervals. The confidence intervals reveal that the uncertainty in estimates of $Q_{0.01}$ may be 50 percent or more of the estimated value. The uncertainty can be understood in terms of probability as well as discharge. It is notable that the 95-percent confidence interval for the 100-year flood overlaps the corresponding confidence intervals for the 10-year and 500-year floods (although the estimated magnitudes differ by about a third in both cases). In short, a 44-year record, which is longer than most streamflow-gaging station records, does not tell us as much as we would like about the population of extreme floods.

Systematic Variability: The concept $Q_{0.01}$ is based on an assumption of *stationarity* – that the flood distribution does not vary over time. However, land-use change and development, in either the watershed or the floodplain, can substantially alter the distribution of floods, in some cases doubling the magnitude of the 100-year peak [Konrad, 2003]. Nonstationarity also may arise due to natural processes. For example, the climate exhibits "modes of behavior" – periods with distinct flood distributions that can persist over relatively long intervals compared with the length of streamflow-gaging station records [Webb and Betancourt, 1992]. As a result, a record of floods collected at a given site during one mode – e.g. a period with frequent El Niño events – may not tell us much about floods at the same site during a period when El Niño events are less common. Climate change, whether driven by natural forces (e.g. the ice ages and interglacials) or human forces (e.g. the greenhouse effect) may also have an impact on flood frequency, although this has not been conclusively demonstrated [Lins and Cohn, 2002]. Engineering works, some of which are designed for flood-control purposes, do change $Q_{0.01}$. However, at present (2004) there are no generally accepted methods for using historical pre- and post-flood control data, along with engineering designs, to adjust estimates of $Q_{0.01}$.

The combination of the sampling variability, the nonstationarity, and other sources of error leads to substantial uncertainty in $Q_{0.01}$. This affects the actual performance of insurance programs and land-use plans, which depend on accurate hazard information.

Looking to the Future

It is worth noting that $Q_{0.01}$ has some attractive properties: It is straightforward to compute, it is reproducible, and it captures precisely a concept – quantification of risk --that insurers and planners require. For these reasons, among others, the concept is likely to persist. Under the circumstances, the following steps would help to improve its application.

- **Reduced Uncertainty**: The uncertainty can be reduced through a combination of more data (and new types of data), better and cheaper instruments, fundamental research, and application of existing technology:
  - Increased temporal and spatial coverage of streamflow records [Hirsch and Costa, 2004];
  - More paleoflood data properly incorporated into flood estimates;
  - Improved understanding of climate modes, such as El Niño, and their influence on floods;
  - Research on how to estimate flood frequency using nonstandard and nonhomogeneous data relevant to watersheds undergoing urbanization or where flood-control works have been constructed.
- **Improved Mapping**: At present, we focus on delineating flood zones corresponding to a small set of exceedance probabilities. However, nature does not respect imaginary boundaries, and planners and residents need to understand the spatial

distribution of the full range of hydrologic risks that they face. The advent of GIS and modern computing allows for mapping a rich set of flood variables *everywhere*: the complete (estimated) distribution of flood depth, velocity, intensity [Fulford, 2004], and other variables.

- **Public Education**: At a practical level, the public needs to understand concepts of randomness and uncertainty in frequency estimates, as well as the need for regulators and insurers to have a bright thin line on a map to represent an idea which is fundamentally fuzzy.

Conclusions

Regardless of what the 1-percent flood standard means in practice, it is an essential concept that supports insurance and engineering/economic planning. The remaining challenge -- achievable through research, monitoring, and technology -- is to improve the correspondence between the abstract concept and the physical world.

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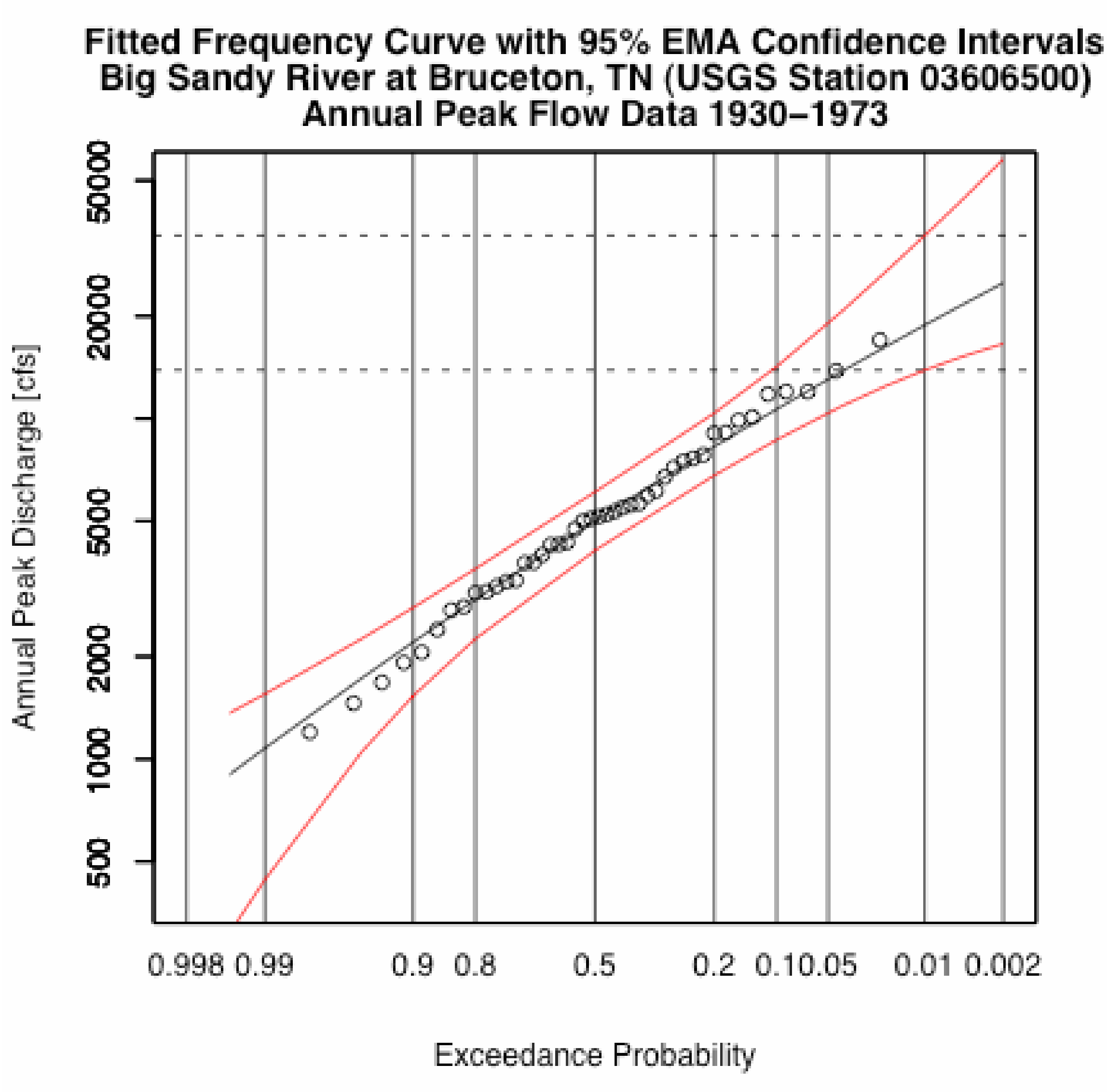

Figure 6: Fitted flood distribution (indicated by straight line through data) with 95% confidence intervals (indicated by curved lines above and below data). Note how the 95% confidence interval corresponding to $Q_{0.01}$ (dashed lines) overlaps confidence intervals for floods with much smaller ($Q_{0.05}$) and larger ($Q_{0.002}$) return periods.

THE BENEFITS OF INTEGRATING PRE-DISASTER MITIGATION AND WATERSHED MANAGEMENT

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The goals of flood risk reduction, improving water quality and protecting aquatic habitat can all be advanced through sound planning and development practices. Floodplains are not only critical determinants of the run-off dynamics for snow melt and high precipitation events, but are critical to the ecological functions of our nation's waters. In addition, over half of the nation's wetlands are located in floodplains. Watershed management principles can help pre-disaster mitigation more accurately estimate and reduce flood risks. With its focus on entire hydrological catchments, watershed management avoids site-specific flood assessments, which do not always consider upstream changes that affect downstream flow. Watershed management also anticipates future changes in development and land-use, changes that then influence flood frequency and intensity. The 100-year flood standard, consequently, should change as watersheds change. Finally, watershed management examines the role wetlands and other aquatic resources play in influencing the movement and storage of surface and groundwater. Together, these features of watershed management could aid pre-disaster mitigation efforts. Better coordination of planning for flood risk reduction and watershed management will achieve multiple benefits to the American public and can be more cost-effective than traditional approaches.

Impervious Surfaces & Development in Watersheds

One of watershed management's strengths is its consideration of impervious surfaces. Changes in impervious cover, such as the construction of paved roads, affect watershed dynamics, mainly by reducing groundwater infiltration and increasing surface runoff. Research demonstrates that stream channels begin to erode when impervious cover approaches 10 percent of a watershed. When imperviousness exceeds 25 percent, channel erosion, habitat degradation and the potential for contamination of drinking water sources is significant.

Development is an important driver of changes in impervious cover. Typically, natural land is nearly 0 percent impervious. Residential lawns, being 40% impervious, absorb less water than natural land. Parking lots can be 95% impervious, indicating that most precipitation exits as runoff. Discontinuous, low-density sprawl fragments the natural landscape, reducing on-site water absorption. Sprawl also requires more roads, further increasing impervious cover.

Smart growth, one critical component of the watershed management toolbox, rethinks traditional development patterns. Smart growth accommodates more people in less space, resulting in less impervious cover and less surface runoff. The principles of smart growth can save local governments money. The Brookings Institution compiled studies that found that smart growth cuts by 70% the portion of development costs borne by state governments. In 2002, Connecticut's taxpayer-funded debt reached $11.8 billion due to the construction of roads, schools and other state-funded infrastructure projects that accompany development. This figure represents 8 percent of the state's total personal income. Finally, the preservation of open space, which aids in water management, can lessen flood risk and damages, leading to lower flood insurance premiums

Spatial and Temporal Aspects of Watershed Management

By definition, watershed management considers the cumulative effects of land-use changes throughout the watershed, not just changes in single sites. The construction of buildings and roads in multiple, seemingly disconnected areas can have significant, cumulative impacts downstream. Changes to natural resources and aquatic habitats—especially the filling and draining of wetlands—can increase flood risks as well. The loss of most wetlands in the upper Midwest, more than 85% in some states, contributed to high floodwaters during the Great Flood of 1993 on the Upper Mississippi River. The flood caused billions of dollars in damage. Another example is the drainage of prairie pothole wetlands in North Dakota, which has exacerbated the frequency and severity of floods in the city of Grand Forks. Wetlands and other aquatic resources provide many important benefits in addition to flood mitigation. They provide critical habitat for fish and wildlife, especially migratory waterfowl. Wetlands also recharge groundwater and serve as natural filters by removing sediment, nutrients and other compounds.

Watershed management incorporates assumptions about future growth into decision-making. A stagnant 100-year flood standard does not reflect these future changes. Furthermore, the minimum requirements of the National Flood Insurance Program do not require communities to consider future changes in the watershed. Communities that voluntarily estimate future growth, however, can earn points from the Community Rating System to reduce insurance premiums. The savings from doing so can be significant. Mecklenburg County in North Carolina expects to save $300 million in flood damages by remapping flood plains—with accompanying development restrictions—to account for future growth.

Conclusion

Clearly, local governments and communities would benefit from the integration of watershed management and pre-disaster mitigation. This integration depends on strong, enduring partnerships among relevant federal agencies, namely FEMA and EPA, as well as various stakeholder groups, including the American Planning Association, the Association of State Floodplain Managers and government agencies at state and local levels. Such partnerships can help achieve multiple objectives, minimize the costs of future development and flood disasters, maximize funding opportunities and promote diverse stakeholder participation.

Part 4

Societal Implications of the 100% Chance Flood Standard

ISSUES AND PERSPECTIVES ON FLOODPLAIN MANAGEMENT

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National Association of Realtors®

ISSUE BACKGROUND

Repeated flooding in the United States and countries across the globe are grim reminders that floods remain a deadly and terrifying natural disaster. In the U.S., floods are the most expensive natural disaster, even though aggressive steps have been taken during the past 30 years to reduce the high cost of floods. According to the Federal Emergency Management Agency (FEMA), 90 percent of all natural disasters are flood-related. Between seven and eight million households are exposed to the risk of flooding, and flooding costs the U.S. an average of $1 billion each year, mainly in the form of commercial and residential property damage.

How Floods Are Managed in the U.S.

The National Flood Insurance Program (NFIP), operated by FEMA, is the federal government's primary tool to manage floodplains and floodplain mapping, and to regulate floodplain development. Congress created the NFIP in 1973, as a response to devastating floods in Texas and Missouri, to provide incentives for communities to manage their floodplains effectively and create a subsidized market for flood insurance. By conducting specific flood mitigation and emergency management activities, communities are allowed to participate in the NFIP and citizens may purchase federally backed flood insurance at an affordable rate. Without the NFIP, flood insurance in flood-prone areas would either be unavailable or prohibitively expensive for homeowners.

REALTORS® Have a Role In Floodplain Management

Approximately 40 percent of the nation's communities are partially located in a floodplain, and with the right weather conditions, a small brook or stream in these neighborhoods can become a raging torrent. Talking with a REALTOR® is often the first time a prospective homebuyer realizes their home or property may be in a floodplain, and the purchase of flood insurance may be necessary. For that reason, REALTORS® need to be informed about floodplains in their communities, where they are located, and the appropriate rules and regulations that govern development in the floodplain.

Effective floodplain management through community participation in the NFIP helps protect lives and property, and REALTORS® have an important role in this process. REALTORS® can assist homebuyers with the NFIP by: (1) understanding what the NFIP is and how it protects property; (2) understanding how to purchase the right amount of flood insurance; and (3) by helping FEMA to identify changes, discrepancies or mistakes in the floodplain.

Accurate maps, that describe the location of the floodplain, are the heart of the NFIP, and REALTORS® can assist FEMA in making sure these maps are up-to-date and correct.

The 1-Percent-Annual-Chance Flood Standard – Should It Be Changed?

The NFIP would not be able to offer insurance at affordable rates without the existence of risk management (floodplain management) to reduce flood losses. In order to assess and manage the flood risk, a national standard was needed. The U.S. Department of Housing and Urban Development, which administered the NFIP before FEMA was created, began its administration of the NFIP by calling on a group of experts to advise the agency as to the best standard to be used as the basis for risk assessment, insurance rating, and floodplain management for the Program. After extensive study and coordination with Federal and State agencies, this group recommended the 1-percent-annual-chance flood (also referred to as the 100-year or "Base Flood") be used as the standard for the NFIP.

The 1-percent-annual-chance flood was chosen on the basis that it provides a higher level of protection while not imposing overly stringent requirements or the burden of excessive costs on property owners. The 1-percent-annual-chance flood (or 100-year flood) represents a magnitude and frequency that has a statistical probability of being equaled or exceeded in any given year; the 100-year flood has a 26 percent (or 1 in 4) chance of occurring over the life of a 30-year mortgage.

In 1973, the Senate Committee on Banking, Housing and Urban Affairs, which had oversight responsibility for the NFIP, heard arguments on both sides on the appropriateness of the 100-year base flood standard. The Committee concluded that the 1-percent-annual-chance flood was reasonable and consistent with national objectives in reducing flood losses. In 1981, the Office of Management and Budget (OMB) directed FEMA to review the use of the 1-percent-annual- chance flood as part of the President's 1981 Task Force on Regulatory Relief. In its report to OMB, FEMA reaffirmed the overwhelming support for the Base Flood standard in responses from the public and private sector.

The 1-percent-annual-chance flood is a regulatory standard used by Federal agencies, and most States, to administer floodplain management programs. The 1-percent-annual-chance flood standard has been used since the inception of the NFIP and is used for floodplain management purposes in all of the 19,200 participating communities that have been issued flood hazard maps.

NAR believes the 1-percent-annual-chance flood standard is a reasonable one. A more conservative standard would impose greater costs and burdens on property owners, builders and NFIP-participating communities to meet building, construction and mitigation requirements for a lower risk of flooding. In addition, the entire NFIP, from the zones and maps to the insurance premiums and building standards, is based on the 1-percent standard. Requiring a more conservative standard would require a dramatic revision of the program and impose significant costs to communities to revise their local and planning codes to stay in the system and continue to receive affordable insurance rates. Any change to the 1-percent-annual-chance flood standard would have to be strongly supported by data, extensive technical research, political and policy support, in addition to the significant financial and budgetary resources that will be necessary to support the requirement at the state and local level.

Other Challenges Facing The NFIP

While it is clear that the flood insurance program has saved lives and property through improved floodplain management, the program has a variety of challenges to address, including:
(1) updating and modernizing the floodplain maps; (2) maintaining the NFIP as equitable and affordable; and (3) making the NFIP more financially and actuarially sound.

Floodplain Maps Must be Updated and Modernized. One of the biggest challenges the program faces is the accuracy of the floodplain maps. These maps describe where floodplains are located in each community across the country. The location of a structure in a floodplain determines whether the owner is required to purchase flood insurance and how much flood insurance is needed. REALTORS® need this information to help their clients obtain the amount of flood insurance that fits within their budget. If the maps are inaccurate, it will cause delays and increase the costs of the transaction. Unfortunately, many of these maps are out-of-date and have not kept up with changes in the floodplain. FEMA estimates the average age of these maps to be 15 years old, and only a small number of them are updated each year. FEMA has estimated that the cost to update the maps and make them more accessible to users would be between $700 and $800 million. Over the past two years, Congress has provided FEMA with sufficient appropriations to jumpstart the map modernization process. The NATIONAL ASSOCIATION OF RELTORS® (NAR) has strongly supported this funding, and will take the lead in advocating for sufficient funding to complete the project.

The NFIP Must Remain Equitable and Affordable. REALTORS® also have concerns about keeping the NFIP equitable and affordable for all program participants. In their efforts to develop new revenue streams for the NFIP, FEMA officials previously have floated a number of funding ideas that would have placed unfair financial burdens on those who own property in a floodplain. One plan would have attached a user fee on all mortgage transactions. Another plan would have required owners of vacation homes in a floodplain to pay more for flood insurance. This would have placed REALTORS® who sell vacation homes in floodplains at a disadvantage because the insurance would be significantly higher on vacation homes, even though both types of homes face the same risk of flooding.

The resulting revenues from both of these plans would have been used to improve and update the maps. However, these maps are used for broader planning, economic development, national security and emergency management purposes. For that reason, NAR has advocated for larger appropriations by Congress to address problems with floodplain mapping.

The NFIP Must Become More Financially and Actuarially Sound. One way to achieve this goal is to phase out subsidies to repetitive loss properties. A repetitive loss property is one that is subject to multiple floods and places a claim into the NFIP more than once. Currently, 45,000 properties nationwide have incurred two or more losses over a 10-year period. These 45,000 properties cost the flood insurance program more than $200 million annually. The top 10,000 structures alone cost the program more than $80 million annually.

NAR supports an approach to the repetitive loss issue that has three components: (1) the property is kept in the NFIP with access to flood insurance; (2) incentives to participate in flood mitigation measures or accept a buy-out at fair market value or higher for the worst repetitive loss properties; and (3) if both the buy-out or the offer of mitigation is refused, the owner will be required to purchase an unsubsidized flood insurance policy. This approach allows the owner to stay in the property, while paying a premium that reflects the risk of living in a floodplain, and places the NFIP on a firmer financial footing.

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REALTOR®

A LEGAL PERSPECTIVE ON THE 100 YEAR FLOOD STANDARD

Jon Kusler
Association of State Wetland Managers

The following paper is based upon a report prepared by the author for the Association of State Floodplain Managers in 2003: *No Adverse Impact Floodplain Management in the Courts.*

Has the 100 year flood standard as the basis for regulation been held invalid in the courts?

As far as I can tell, no court in the more than 400 state and federal floodplain regulatory cases in the last thirty years has held that the 100 year flood standard is unreasonable or otherwise invalid as the basis for mapping or regulation.

Has a national standard (i.e. the 100 year flood standard) helped build judicial support for flood plain regulations over the last three decades?

I believe so. Prior to adoption of the 100 year flood standard in the late 1960's for flood mapping and regulations, a broad range of ad hoc standards were applied. Floodplains were often mapped based upon air photos or one the ground evidence of flooding without assigning a frequency. Various "regional" floods were adopted for mapping and regulatory purposes but they too involved somewhat ad hoc determinations.

Adoption of the 100 flood standard for mapping and regulation gave greater uniformity to regulations and reduced arguments that maps and regulations were arbitrary and discriminatory. Although few courts have held floodplain regulations discriminatory, discrimination and arbitrariness are two factors considered by courts in deciding whether regulations are a taking of property. Regulations which are discriminatory have a greater chance of being held a taking. See, for example, Morris County Land Imp. Co. v. Parsippany-Troy Hills Tp., 193 A.2d 232 (N.J., 1963) in which the court in this early case invalidated in total a wetland conservancy district which permitted no economic uses where the district was primarily designed to preserve wildlife and flood storage for downstream landowners.

Have courts upheld floodplain regulations which require protection exceeding the protection normally associated with a 100 year standard?

Federal Emergency Management Agency (FEMA) statutes and regulations provided that more restrictive state and local requirements take precedent over NFIP minimum standards. Courts have sustained a range of floodplain regulations which exceed the specifically articulated minimum standards of FEMA against challenges that they are unreasonable or a taking. These include regulations which use flood protection frequency intervals which exceed the 100 year flood. See, for example, American Cyanamid v. Dept. of Envir. Prot., 555 A.2d 684 (N.J., 1989) in which the court held that N.J. DEP could use U.S. Geological Survey 500-year design flood line for regulatory purposes.

Courts have also sustained regulations which more tightly control activities within the 100 year floodplain than would be allowed pursuant to FEMA minimum regulations. See, for example, Hansel v. City of Keene, 634 A2d 1351 (N.H., 1993) in which the New Hampshire Supreme Court upheld an ordinance adopted by the city of Keene which contained a “no significant impact” standard. The zoning ordinance, prohibited new construction within the floodplain unless it was demonstrated “that the cumulative effect of the proposed development, when combined with all other existing and anticipated development, will not increase the water surface elevations of the base flood at any point within the community.” In sustaining the regulation, the court noted that the floodplain ordinance revealed “an understandable concern among city officials that any water surface elevation increase in the floodplain could, at a minimum, strain city resources and impose unnecessary hardship on city residents.”

For other examples sustaining regulations which exceed minimum FEMA standards see, for example, New City Office Park v. Planning Bd., Town of Clarkstown, 533 N.Y.S.2d 786 (N.Y., 1988) in which the court upheld planning boards denial of site plan approval because the developer could not provide compensatory flood storage for 9,500 cubic yards of fill proposed for the property. The court noted that “Indeed, common sense dictates that the development of numerous parcels of land situated with the floodplain, each displacing only a relatively minor amount of floodwater, in the aggregate could lead to disastrous consequences. See also Patullo v. Zoning Hearing Bd. of Tp. of Middletown, 701 A.2d 295 (Pa. Cowlth, 1997) (Court held that landowner was not entitled to a special exception or variance for construction of a garage in a 100 year floodplain where construction would have raised flood heights by .1 foot.. Finally, see State v. City of La Crosse, 120 Wis.2d 263 (Wis., 1984) (Court held that state’s hydraulic analysis showing that fill placed in the La Crosse River floodplain would cause an increase greater than 0.1 in the height of the regional flood, contrary to the city’s floodplain zoning ordinance and state regulations.)

Does government or private compliance with 100 year standard prevent suits by private landowners against governmental units undertaking activities which may increase flooding and erosion?

No. Landowners must act always “reasonably” with respect to other landowners to avoid potential liability pursuant to common law theories including “negligence”, “riparian rights”, the “reasonable use” theory for surface water and, to a lesser extent, “nuisance”. See, e.g., County of Clark v. Powers, 611 P.2d 1072 (Nev., 1980). Reasonableness depends upon the context including the severity of harm posed by particular types of activities. In general, any activity which substantially increases the amount, velocity or depth of surface waters on other lands has been held by courts to be unreasonable and potentially subject to liability. See, e.g., Lombard Acceptance Corp. v. Town of San Anselmo, 114 Cal. Rptr. 2d 699 (Cal. App., 2002) in which the court issued an injunction against a town for unreasonable increases in surface water which caused a landslide.

Although violation of a statute or ordinance is, at a minimum, evidence of negligence, compliance with an ordinance or statute does not bar a negligence suit. Corley v. Gene Allen Air Service, Inc., 425 So. 2d 781 (La., 1983). In addition, approval of a permit for a project by a state administrative agency does not preclude a private law suit. For example, in Oak Leaf Country Club, Inc., v. Wilson, 257 N.W.2d 739 (Ia., 1977) an Iowa court held that approval by a state agency of a stream channelization project did not preclude judicial relief to riparian landowners for damage from the project.

The standard for reasonable conduct in a negligence suit is usually a community standard. Therefore, evidence of the usual and customary conduct of others under the circumstances is relevant and admissible. However, courts have found an entire industry careless and custom is not conclusive. See The T.J. Hooper, 60 F.2d 737 (2nd Cir., 1932). As noted by the Illinois Supreme Court in Advincula v. United Blood Servs., 678 N.E.2d 1009 (Ill., 1996) “while custom and practice can assist in determining what is proper conduct, they are not conclusive necessarily of it. Such evidence may be overcome by contrary expert testimony (or its equivalence) that the prevailing **professional standard of care** *(emphasis added by the court)*, itself, constitutes negligence.”

Do advances in the science of floodplain management increase the probability that landowners will successfully sue governmental units for failing to exceed the 100 year standard in some instances?

Yes. The standard for government liability is, in most instances, the reasonableness of government actions. The potential for private and government liability has increased as the techniques and capabilities for defining hazard areas and predicting individual hazard events have improved and actual mapping of hazard areas has taken place. Advances in hazard loss reduction measures (e.g., warning systems or elevating structures) create an increasingly high standard of care for reasonable conduct. As technology advances, the techniques and approaches which must be applied by engineers and others for “reasonable conduct” judged by practices applied in the profession also advance. Widespread dissemination of information concerning techniques for reducing flood and erosion losses through magazines, technical journals, and reports, has also broadened the concept of "region" so that a broad if not national standard of reasonableness may now exist.With improved predictive capability and the actual mapping of areas, hazard events are now (to a greater or lesser extent) “foreseeable” and failing to take such hazards into account may constitute negligence. See, e.g., Barr v. Game, Fish, and Parks Commission, 497 P.2d 340 (Col., 1972.)

“Act of God” was, at one time a common, successful defense to losses from flooding and erosion. But, at common law, “acts of God” must not only be very large hazard events but must also be “unforeseeable”. See, e.g., Barr v. Game, Fish, and Parks Commission, 497 P.2d 340 (Col., 1972.) See also, Lang et. al v. Wonneberg et. al, 455 N.W.2d 832 (N.D., 1990); Keystone Electrical Manufacturing, Co., City of Des Moines, 586 N.W.2d 340 ((Ia., 1998). Improved predictive capability and the development of hazard maps for many areas have limited the use of this defense.

RAISING THE NATIONAL STANDARD FOR FLOOD PLAIN MANAGEMENT— EDUCATION OF THE PUBLIC AND POLICY MAKERS

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Chair, U.S. Army Corps of Engineers National Nonstructural/Flood Proofing Committee
and
Chief, Hydrologic Engineering Branch, Engineering Division, Omaha District, Northwestern Division, U.S. Army Corps of Engineers

Reference my paper of June 15, 2004 entitled "Reducing Flood Losses: Is the 1% Chance Flood Standard Sufficient". In that paper I addressed that a need exists for raising the National flood plain management standard above the 1% chance flood and I also addressed how the Nation gets that done. I stated that the most critical element of the dialogue of "is the 1% chance flood standard sufficient" is not whether it needs to be raised but rather how it gets raised. I stated that this most critical element of getting the standard raised consists of identification of the need for the raising the standard, evolution of the need for raising the standard, determining the increased level of flood standard that is appropriate and that is implementable, education of the public and policy makers, timing for the introduction of the concept as a National focus, and ultimate implementation of the law/policy. In this paper, I will be more specific by addressing the most critical element of "Reducing Flood Losses: Is the 1% Chance [100-year] Flood Standard Sufficient". That most critical element is "Education of the Public and Policy Makers". This paper will be devoted to that element.

Education of the need for a higher National standard of flood plain management must occur at basically four levels:

--citizens that can be affected by floods and flood plain regulations

--representatives of local government that are directly responsible for implementing flood plain management

--agency representatives at State and Federal governments that implement flood plain management regulations either directly or indirectly

--elected public officials especially at the local and Federal level who must support and/or achieve the legislation needed to raise the National flood plain management standard.

This education process really needs to start with agency representatives at State and Federal governments that deal with flood response, flood recovery, and flood plain management. These people are already familiar with the existing National flood plain management program. They are also familiar with many locations where floods larger than the 1% chance have occurred and have resulted in substantial damage that was not protected. These are the people that must demonstrate the need for raising the National standard to the other three levels stated above. This level will be responsible for development and implementation of the most essential part of this standard raising initiative--outreach and education. If this level is not engaged and supportive of the standard raising objective, this initiative will fail.

The next step in the education process is to educate the representatives of local government [staff] that are directly responsible for implementing flood plain management and who interact on a near daily basis with citizens that can be affected by floods and flood plain regulations. Without buyin from the local staff, it will be near impossible to reach out to the other remaining levels [citizens and elected public officials] who will be most instrumental in actually getting higher standards enacted into law. Local staff probably have many examples in their own communities of jurisdiction where a higher level than the 1% chance flood is needed for flood plain management. They have personally seen the adverse impact on their community of floods occurring that exceeded the National flood plain management standard. Many of these communities are already implementing higher standards of flood plain management and are eagerly awaiting the National standard to again lead the way to stronger and better flood plain management. These people [local staff] will also have to deal with those opposed to a raised National standard. Those opposed are generally concerned about the adverse impacts to local economies and individual property rights. These impacts can be argued very strongly from a somewhat short term visionary perspective. It is the local staff who must have the information to deal with these more short term visions and who must have the ability to realize locally when the time is right to move forward with advancement in raised flood plain management standards in terms of citizen buyin and ultimate elected official legislation to accomplish the raised standards. Some have already done this successfully.

The education process ultimately must lead to the elected public officials at the local and Federal level who must support and /or achieve the legislation needed to raise the National flood plain management standard. Citizen education and support would help achieve the ultimate legislative initiatives that need to be accomplished by the elected officials. This can only be accomplished through a solid outreach program focused on the problems created by an inadequate National standard, the logic behind a raised National standard, and the long term vision in terms of reduced flood hazards and realization of other resultant opportunities.

Education is the key to reaching success in raising the National flood plain management standard above the current 1% flood. This must be a focused effort at the four basic levels discussed above through a solid outreach program.

INSURANCE ALONE IS NOT ENOUGH —UNDERSTANDING THE FLOOD HAZARD IS THE KEY

Clive Q. Goodwin
Assistant Vice President & Manager Flood Underwriting / Engineering, FM Global

It is critical to recognize the importance of maintaining and improving flood information available through the FEMA flood maps. In addition to the obvious benefits provided by the National Flood Insurance Program (NFIP), the information is used extensively by those responsible for risk management of our infrastructure and industry. Having Utilities, Municipalities and Hospitals operational during period of disastrous storms or flooding is essential to reduce the scale of the disaster and the demands on Federal Assistance.

There is little doubt that the introduction of the 1% chance flood as the benchmark for developing "Special Flood Hazard Area" flood zones and mapping The Nation was an excellent step forward. Unfortunately the long-term use of this single standard criteria has lead to an "in / out" mentality amongst communities, developers and industry in general. The very nature of the FEMA flood maps leads to a simple "Black & White" approach.

Each year we see 1 in 4 flood losses occur outside published flood zones. When flooding occurs outside these zones the level of damage and impact to businesses is typically more extreme than for similar events within the zone. The reason for this is primarily one of lack of awareness or understanding of the hazard and not being prepared. If the owners or occupiers of these properties understood the hazard of being just beyond the 1% chance flood prediction, the outcome would be very different.

The key is to increase awareness of the flood hazard and the potential impact to the property owner or business affected. To be effective, the starting point should be severity and <u>not</u> frequency. It is absolutely critical that the magnitude of predicted damage and disruption is understood. The property or business owner can then make a decision as to whether this is an acceptable risk or not in terms of lost valuables, business impact and life safety. Nine times out of ten, when the hazard and impact are understood, the owner concludes that the risk is unacceptable and seeks to reduce the impact through physical changes (often as simple as removing valuable from basements) or making emergency plans. The frequency of occurrence is a secondary consideration and only becomes a point of discussion if the impact of the event is considered acceptable. A well informed property owner is likely to seek mitigation and risk transfer (insurance) options available beyond those imposed by the NFIP.

There are areas where flood is less of a risk and more a certainty. Within the black areas on the FEMA flood maps (designated as the 1% chance flood footprint), there are areas that are far more at risk. Historically we focus on properties with repeat losses as those at most risk. Clearly this is an indication, but hardly a scientific answer. With the technology available today we should be able to delineate between areas of differing hazard and in particular identify areas where repeat flooding is inevitable.

From an industry prospective, it is critical to consider potentials beyond the “1% chance flood” from both a business survival standpoint and to meet the risk management demands of stock holders and the regulatory authorities. To put this in prospective, the chance of a manufacturing business having a fire is approximately 1 in 100 (1% chance) and subsequently normal operating procedures dictate that there be automatic sprinklers and emergency response plans to mitigate

the risk and keep the business operating. Without sprinklers and the emergency plan, the event would likely be devastating. Having solely insurance coverage in place is not a realistic option as it cannot ensure business continuity and often by the time repairs are made, competitors have moved in on the business. The provision of sprinklers is therefore demanded by society and stock holders alike as it reduces the chance to approximately 0.03%.

It is therefore far more likely that a sprinkler protected factory located within the “1% chance flood” footprint have a major disruption due to flood than fire. Clearly it is therefore imperative that we continue to identify flood risks beyond the “1% chance” level in order that the risk management approach within US industry supports its long-term livelihood. With more and more rationalization with single source factories, any glitch in the supply chain can lead to delays in production handing the opportunity to competitors often abroad. It is also important to consider the risk management needs of Utilities, Hospitals and other important parts of our community that have risk management responsibilities. All of these rely on companies like FM Global to help them manage their risk and provide insurance capacity as needed. Continuity of operation of these providers in times of a major storm or flood has a major impact on the scale of the disaster and demands for Federal assistance. To support the needs of industry and the community, we need to ensure that all foreseeable sources of flooding up to at least the “0.2% chance” level are identified and published.

The “1% chance” FEMA flood maps have a myriad of caveats covering items such as small streams and areas of minimal flooding that are not clearly identified. This together with the fact that as time passes more areas are becoming subject to street flooding caused by urbanization leads to a significant misunderstanding of the hazard.

To be successful in educating the community and promoting sound mitigation policy at both local and regional level, we must routinely identify areas subject to potential flooding in the future, key items include;

- Areas not evaluated previously due to small streams
- Areas subject to street flooding
- Areas at risk of minimal (<1ft deep) sheet flow flooding
- Areas protected by levees
- 0.2% chance of flooding

With the latest technology we can identify areas at potential risk by using rainfall and run off models. For the areas outside the traditional “Special Flood Hazard Areas” there is no need to replicate the same level of perceived accuracy demanded by the legislation surrounding the enforcement of the NFIP.

The optimum solution is to;

1. Maintain the existing 1% benchmark for SFHAs
2. Identify “High Hazard” areas that are prone to reoccurring flooding and unsuitable for inhabitation or development.
3. Clearly identify areas prone to less frequent flooding due to
   - Small streams & ditches
   - Street flooding
   - Sheet flow flooding
   - Levee overtopping or operational failure
   - 0.2% chance of flooding (regardless of the source)

Identifying Flood Hazards and educating all players as to the hazard and impact to their belongings and businesses is the key to long-term mitigation success. It also leads to a far better prepared community with utilities and vital services prepared to withstand foreseeable storms and flooding.

COMMUNICATING WHAT THE 1% CHANCE FLOOD MEANS

Robert Ogle
National Flood Determination Association

Since we are not direct witnesses to specific ground issues that have led to this debate, our comments as to the viability and or reasonability of the current standard stem directly from customer service related issues we deal with on a daily basis. Therefore, any change we feel imperative, relative to the current standard, forms itself from our desire to improve public perception, thereby improving public relations for all parties either directly or indirectly involved in the flood zone determination process.

In 2003, our industry answered over 1.3 million customer service calls on behalf of our clients. The overwhelming majority of these calls reflect a true lack of understanding on the part of the general public, as well as, local flood plain officials, surveyors, and insurance agents. Although more and more consumers have been made aware of the potential risk of loss due to flooding, as a result of the cooperative efforts of the NFIP, the NFDA, and the ASFPM, a great amount of confusion still exists.

At the time the "100-year" standard was created, it was done as the basis for risk assessment, insurance rating, and floodplain management. The term "100 year flood" was used to simplify the definition of a flood that statistically has a 1 percent chance of occurring in any given year. However, it is not a term that is being clearly understood in the marketplace.

Unfortunately, the majority of available publications do not effectively communicate that the term is used to represent the magnitude (or depth) in addition to the frequency of a flooding event. While the explanation of the "1 percent chance" in a given year is often used, in an effort to put the event in a better time perspective, the "1 percent" doesn't bode well for this being a "big flood".

Also, the lack of a clear and concise definition leaves many to view it simply in terms of - a flood that will happen once every 100 years. This is the most common 'myth' that our customer service personnel deal with each day.

We all agree that a standard is needed to quantify flood risk. But, it must be understood that we deal with many different audiences/stakeholders who have different levels of understanding regarding technical terms behind the definition.

While the engineering and floodplain management constituency of the NFIP need a statistical definition, the average consumer, who is risk-averse to buying flood insurance, needs a risk assessment definition that can be put into perspective.

Therefore, we would like the forum to address the fact that the public, including those who act on their behalf, needs to clearly understand the definition of the various flood zone designations, and the respective risk levels associated with each designation.

LENDERS AND THE 100-YEAR BASE FLOOD

Michael Moye
President
National Lenders' Insurance Council

Aside from understanding the misunderstandings created by the terms 100 and 500 year floodplain, most lenders accept the standard, albeit with some misgivings, and leave the technical aspects of its definition and application to the experts. A lender's main concern revolves around compliance with federal regulations and investor guidelines that require the purchase and maintenance of flood insurance when collateral property is, or is to be, located within a Special Flood Hazard Area (SFHA). While investor guidelines require all borrowers to purchase and maintain fire insurance, only those borrowers within SFHA's are required to purchase and maintain flood insurance. That mandate creates an adverse selection process fraught with perplexing, inconsistent and sometimes unworkable rules that create seemingly endless customer service and compliance issues.

Regulated lenders and lenders who sell and service Government Sponsored Enterprise (GSE) loans have devoted significant resources to understanding and implementing the mandatory flood insurance requirements. They have sent representatives to the National Flood Conference and have participated with other stakeholders in meetings, workshops and forums in an effort to better understand floodplain management and the flood insurance program and the ways both impact their business and their customers. Through that participation, lenders have come to harbor nagging doubts that the 100 year base flood standard's probability of a 1% chance occurrence in any given year is accurate, or that it is accurately applied.

Lenders know that the map inventory lags behind current and changing conditions on the ground despite the map modernization attempt at catch up. They have learned that new construction and letters of map change based on fill alters the topography and can create changes in the watershed endangering other properties that may not be shown to be in the 100 year floodplain. They read reports and articles that suggest the base flood standard is unevenly and inconsistently applied, and that the standard itself does not recognize common flood occurrences such as debris blockage of culverts and other run off avenues. They listen with disbelief when they hear the standard defined as the flood elevation that has a 1% chance of being equaled or exceeded in any given year, and then receive a Letter of Map Amendment that is granted on the basis of a fraction of an inch over the base flood elevation.

At present there doesn't exist measures to demonstrate economic loss to the lending community due to an inadequate or inconsistently applied base flood standard. It is important to acknowledge that there is no history of loan default because of an uninsured flood loss, at least not in the last half century or more. Somehow, those with mortgages who suffer devastating flood losses without insurance manage to continue payments or obtain relief in a manner that makes the mortgage holder whole, e.g. buyouts and other federal and state disaster relief programs.

Currently, lender costs come in the form of counseling those who are required to buy flood insurance on the subject of its fair application, or in counseling those who have uninsured flooded property ostensibly located in a 500 year floodplain. Because of a perceived rise in flood occurrences on properties lying outside the SFHA, the lending community has become more suspicious of the standard's accurate application. Even if the misleading nomenclature can be overcome through better education and communication, the spectre of inaccuracy will stand, particularly since the standard serves as the determinant for the purchase of flood insurance.

Mindful that development and construction proceed in accordance with a property's floodplain designation, the lending community wants the mandatory program based on an accurate and consistently applied standard which balances safe land use with economic benefit, a standard that can be easily interpreted and understood, so that borrowers know the risk and will act responsibly. The lending community will willingly devote resources for education and communication of such a standard, whether it be the current standard accurately applied, or one that finally may be found to be more appropriate.

THE ENHANCED BENEFITS ACCRUED FROM INCENTIVE-BASED PLANNING VERSUS REGULATORY PLANNING

Cherry Jackson
Mayor, Thompson's Station, Tennessee

When planning for or reacting to the pressure of growth, many communities face three options. One is to oppose the growth altogether. This is highly unrealistic, as the world adds six million people to its fixed surface area every month. The more rational options address the pattern of the town's growth, and the viable ways to manage it. Rather than allow urban sprawl to overtake it in its tracks, small towns can and should have the autonomy and planning devices in place to control the fate of their growth. Another issue is to address the type of planning a town must do to ensure its character is preserved while also allowing for the necessary growth to take place. Can the growth pattern have a higher density of housing units while preserving the character of the town? The answer is yes.

A good way to understand the philosophy of incentive-based planning is to examine the proposed Conservation Security Act of 2000. The Act sought to compensate farmers for their practices that conserve and protect soil, water, wildlife, wetland resources and that reduce air and water pollution, mitigate flooding and sequester carbon and phosphorus. The proposed legislation recognized that every acre of properly managed land had the potential to produce a range of environmental benefits. Rather than pay crop subsidies to farmers, the farmers would be reimbursed for the environmental benefits they provided for society. To date, the Bill was not enacted.

Despite this, the philosophy embodied in the Conservation Security Act can be applied to the management of floodplains in urban settings. Owners/developers of sites containing floodplains and wetlands generally set aside those areas as open space to comply with prescribed regulations—the 100-year floodplain and the delineated regulatory wetlands. This 'regulatory' approach usually deducts these jurisdictional lands from the development density. This action reduces the entitlements granted for the development and diminishes the value of the land. A by-product of reducing density is aggravated urban sprawl in order to accommodate growth. More land is converted to urban uses, which adversely affects the town's character.

Owners/developers can be challenged to develop plans that provide an array of environmental benefits, e.g. nonstructural drainage, floodwater storage, nonpoint pollution mitigation, groundwater recharge, native vegetation landscaping, habitat areas, carbon sequestering, wastewater reclamation and reuse (complete the nutrient cycle) and public open space. Each acre of land in the development preserved as open space can be managed to secure these multiple benefits. The owners/developers, like the farmers in the proposed Conservation Security Act, should be compensated for the environmental benefits they provide and the community problems they solve.

This can be done without securing and allotting federal, state or local funds. Instead of using taxpayer money to encourage owners/developers to formulate environmentally sound plans, local governments compensate the owner/developer for the environmental benefits provided by increasing the number of lots in the development plan. The number of additional lots would reflect the environmental scope, importance and magnitude of the benefits provided.

In this way, environmental benefits are secured and organized by the owners/ developers of the land, not the taxpayers. In incentive-based planning, society secures benefits that increase the quality of life without the need to appropriate funds or secure state and federal funding. With incentive-based planning, the clustered housing (higher density) deters the continuation of linear urban sprawl and its accompanying traffic gridlock. The public benefits are paid for by the owner/developer who is stimulated to act by the award of "bonus lots".

It is important to realize that the goals of both regulators and owner/developers are not always contradictory. An owner/developer wants a project to cater to the needs of the public (the homebuyers) while the regulator also wants to foster an environment that will benefit the public (not only the homebuyers but also the public at large). Therefore, many decisions an owner/developer and a regulator make in planning a development are not in fundamental disagreement. It is an advantage for each party involved to work together to ensure that an array of environmental benefits are enjoyed by residents both within and outside the development.

THE 1% STANDARD – AN APPROPRIATE IDENTIFICATION OF RISK

Christopher S. Galik
National Association of Home Builders

The Federal Emergency Management Agency's (FEMA) National Flood Insurance Program (NFIP) plays a critical role in directing the use of flood-prone areas and managing the risk of flooding for residential properties. Therefore, the National Association of Home Builders (NAHB) fully supports the Congressional finding that, "as a matter of national policy, a reasonable method of sharing the risk of flood losses is through a program of flood insurance which can complement and encourage preventive and protective measures."[1] The larger question, however, is the level of risk that may be considered "reasonable" in the context of these flood losses. NAHB believes that the 1% chance, sometimes called the 100-year flood standard, is fully sufficient in this regard.

The 1% chance flood standard addresses those areas that are most problematic without imposing burdensome requirements on less probable areas. Indeed, FEMA has itself identified the 1% standard as appropriate after consideration of a number of alternatives.[2] The end result is a flood insurance program that effectively identifies and focuses resources on those areas that are of primary concern. The 1% standard allows for a reasonable national standard that still preserves state and local flexibility in floodplain management and decision-making. Through implementing regulations adopted at the local level, communities can take into account specific economic needs, maintain inventories of buildable land, and protect citizens and property alike. Communities can use local rules and regulations to meet local needs, incorporating or oftentimes exceeding the NFIP's *minimum* requirements. Changing the national standard not only presupposes that these communities have developed their regulations and restrictions with little or no attention paid to local conditions, risks, and requirements, but assumes that they are inadequate in protecting their own citizens. A change in the national standard would also require a wholesale updating of Flood Insurance Rate Maps (FIRMs) at a scale well beyond the current map modernization effort. In addition to the remapping effort itself, outreach to the thousands, if not millions, of individuals whose location in relation to the floodplain may have significantly changed would consume massive local, state, and federal resources.

In truth, the focal point for floodplain management should not be modification of the NFIP's minimum standard but on addressing the tremendous payouts to so-called repetitive loss structures. Annually, the NFIP pays out nearly $200 million, or 25% to 30% of all claims, to repetitive loss structures. These properties, which account for but a fraction of the 4.4 million NFIP policyholders nationwide, are both a tremendous drain on the NFIP and a continuous and unacceptable risk to loss of life and property. The recurrent drain that repetitive loss structures inflicts on the NFIP is not due to the failure of the 1% standard, however; rather, a great majority, 96%, of these offending structures were in place prior to the

[1] 42 U.S.C. § 4001(a)(3)

[2] "The 1% annual chance standard was chosen after considering various alternatives. The standard constitutes a reasonable compromise between the need for building restrictions to minimize potential loss of life and property and the economic benefits to be derived from floodplain development." Federal Emergency Management Agency. Flood Hazard Mapping Frequently Asked Questions. http://www.fema.gov/fhm/fq_term.shtm, Accessed August 6, 2004.

first flood maps and are simply a stubborn holdover from an era when floodplain management was often neglected.[3] Simply changing the minimum standard or base flood elevation from 1% will do nothing to address the *existing* repetitive loss problem.

As the scale of the repetitive loss problem becomes more and more apparent, there are increasing numbers of measures being added to address the issue both nationally and locally. In Congress, there has been significant attention paid recently to the repetitive loss crisis under the NFIP as well as to the steps by which to remedy the unacceptable risk and financial outlays that repetitive loss structures represent.[4] On the ground, local communities are moving to address repetitive losses and working to minimize loss to new and future structures through careful management of floodways and floodplains.[5] Regardless of the frame of reference, be it local or national, it is apparent that the true challenges of the NFIP lie in those structures sited and built prior to the institution of the 1% standard and not the standard itself.

As the voice of the home building industry, NAHB fully supports the aims and goals of the NFIP. Through thoughtful identification of a reasonable flood risk and strategies by which to minimize or mitigate that risk, communities can protect their residents while providing adequate latitude for growth. For decades, the 1% standard has served to identify those areas of reasonable flood risk, while providing localities the broad latitude to meet their particular needs. NAHB believes that a standard more stringent than 1% would fail to significantly improve the protection to life and property under the NFIP, while unintentionally increasing outreach commitments, undercutting existing community-based floodplain management, and failing to address the true drain on NFIP resources – pre-FIRM repetitive loss structures. In the context of the NFIP, NAHB fully believes that efforts should be focused on correcting problems of the past rather than retooling a standard that has proved more than adequate. Current initiatives at all levels of government, local, state, and federal, set up mechanisms by which to address repetitive loss, and should be allowed to continue unimpeded by an unjustified shift in national standards.

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[3] "The statistics show that 96 percent of the repetitive loss properties are what are called pre-FIRM properties. These are before FEMA went in and began mapping the floodplain. So a lot of people are in the floodplain that didn't realize they were getting into it in the first place that are being caught up in the repetitive loss property" Statement of the Hon. Richard H. Baker, a Member of Congress from the State of Louisiana, The National Flood Insurance Program and Repetitive Loss Properties Hearing Before the Subcommittee on Housing and Community Opportunity of the Committee on Financial Services. U.S. House of Representatives. 107th Congress, First Session. July 19, 2001

[4] The Bunning-Bereuter-Blumenauer Flood Insurance Reform Act of 2004, which was signed into law on June 6, 2004, establishes a pilot program under which the Director of the Federal Emergency Management Agency (FEMA) may provide financial assistance to States and communities for taking actions to mitigate flood damage to severe repetitive loss properties.

[5] By way of example, the city of Austin, Minnesota has halted new development in repetitive loss areas while working to relocated or removing existing structures. http://www.ci.austin.mn.us/Engineering/flood.htm, Accessed August 5, 2004.

PERCEPTIONS OF RISK FOR THE 1% CHANCE FLOOD

James K. Murphy
Michael Baker Jr., Inc.

Traditionally, when evaluating a standard such as the 1-percent-annual-chance flood standard used by the Department of Homeland Security's Federal Emergency Management Agency (FEMA) and the National Flood Insurance Program (NFIP) as the basis for establishing flood insurance requirements nationwide, experts would look at the appropriateness of the standard from technical, economic, and historical viewpoints. Regardless of the positions reached by looking from each of these viewpoints, it also is critical to consider how the flood hazard and risk information related to the standard is conveyed to the user community nationwide. This is not to say that the technical, economic, and historic viewpoints are not valid.

As the rapid evolution of Geographic Information Systems, remote-sensing, and other technologies continues, it is very appropriate to consider whether the technical basis for the 1-percent-annual-chance flood—and the depictions of the associated Special Flood Hazard Areas (SFHAs)—is still solid. Likewise, it also is appropriate to consider the economic effects of making any change to the standard because of its direct relationship to flood insurance purchases and the associated rating structure. In addition, no final decision can be made without looking at the historical basis for the standard.

However, it is clear from the establishment of objectives for the Multi-Hazard Flood Map Modernization initiative (Map Modernization) that proper communication of the standard and the risk associated with the establishment of that standard is critical. Two of the four objectives of Map Modernization read as follows:

1. *Build and maintain mutually beneficial partnerships*—Foster mutually beneficial partnerships that achieve shared outcomes through the communication of flood risk and other hazard information and improve the systems that support them. Partnerships will result in enhanced delivery of risk management applications and operations; and
2. *Expand and better inform the user community*—Foster public and stakeholder understanding of where to obtain flood and other hazard data and how to use and analyze it in order to make sound decisions to reduce vulnerability to natural and manmade hazards

The need to improve the user community's understanding of flood hazards and their associated risk to life and property is not a new issue. In fact, FEMA adopted the use of "1-percent-annual-chance flood" in the late 1980s in an effort to more adequately describe the probability of the occurrence of the flood and to minimize the confusion of a wide segment of the U.S. population who believed (and, in some cases, still believe) that the "100-year flood" is the flood that occurs every 100 years. In published documents (e.g., FEMA 258, *Guide To*

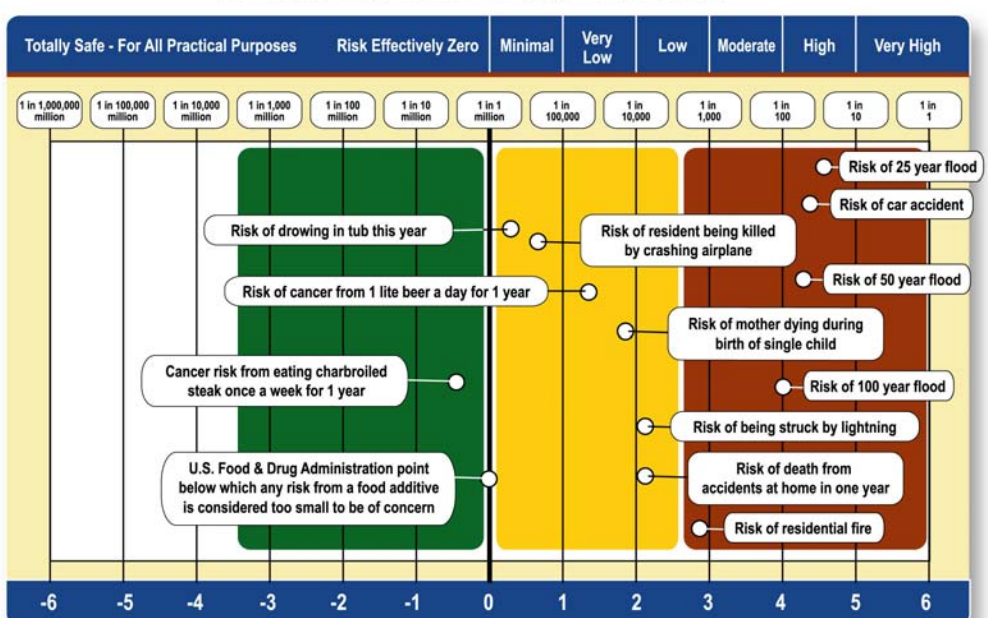
Flood Maps), FEMA has attempted to further clarify the probability of such a flood occurring, saying that it has approximately a 26-percent chance of occurring during a 30-year period, which is the length of most home mortgages. In addition, numerous respondents to the FEMA Call for Issues in 1997-98 recommended that FEMA stop using “100-year flood” and “500-year flood” on any NFIP-related products.

As part of the Map Modernization effort, FEMA and its partners at the Federal, State, and local level will need to develop effective messages that will influence the full user community’s rational and emotional sides to get them to take action. These messages will need to recognize that people are overwhelmed with data and facts; thus, facts that are out of context do not and will not influence the user community. FEMA and its partners will need to present facts in a context that is understandable to the audience. For instance, one method of communicating risk is by comparing the likelihood of disastrous events. Dr. John Paling, a nationally recognized risk expert and a member of the National Service Provider team, has developed the Paling Perspective Scale presented below as a simple tool to help in the decision-making process. As shown in the scale, the likelihood of experiencing floods of different magnitudes are compared with such seemingly disparate risks as getting cancer by eating charbroiled steak or drowning in your bathtub.

Dr. Paling and Dr. David Ropeik, nationally recognized risk communication expert from the Harvard Center for Risk Analysis, have developed tools to assist the Department of Defense and the health care industry in communicating risk. Drs. Paling and Ropeik could be called on to craft effective risk communication messages and tools once a final decision regarding the 1-percent-annual-chance standard (or any new standard) is reached. Recommendations that

The Paling Perspective Scale©*

A simple tool to help decision-making by America's Leaders



* The Paling Perspective Scale©
"Helping the Public put Life Into Perspective"

Dr. Ropeik already has offered for consideration are renaming the 1-percent-annual-chance flood and 0.2-percent-annual-chance (500-year) flood to eliminate confusion about definitions and evaluating the creation of products that show flood insurance risk zones with colors (e.g., red for high risk, yellow for moderate risk, and green for low risk).

The study of risk perception also has revealed that humans tend to fear similar things for similar reasons, and they subconsciously "decide" what to be afraid of and how afraid to be. When developing risk messages, FEMA and its partners will need to consider an assortment of risk perception factors that affect how the messages are received, including:

- People are more afraid of manmade risks than those caused by nature.
- The greater the uncertainty about a risk, the greater a person's fear is likely to be.
- People don't perceive risks to society as fearfully as they do if those same risks may affect them personally.
- People fear more greatly those risks that threaten future generations.
- People are more fearful of a risk if they know of a specific instance of that risk affecting someone (versus a risk being a statistical reality but one with which people have no associations).
- The more aware of a risk people are, the more concern it raises.

In the future, FEMA and the National Service Provider would like to use visualization techniques to develop innovative solutions for the display and understanding of complex multi-hazard environments. Through the design, development, and implementation of multi-hazard models and applications, FEMA will be able to immediately adopt/adapt/apply existing capabilities with analytical tools that enable users to be better informed to reduce their risk and vulnerability to hazards.

Integration of advanced technologies such as ESRI's ARCGlobe® Flood Data 'Fly-Thru' visualization tool could provide advanced risk communication tools to FEMA's hazard mitigation efforts, as evidenced in the visualization of FEMA flood data for Clark County, Nevada.

In addition to improving risk communication about general flood hazards, an additional area of concern that should be addressed is the risk to people living in landward areas behind levees, many of which no longer provide the extent of flood protection for which they were originally designed. One way to make people aware of this risk would be to create a distinct flood insurance risk zone designation. Respondents to the FEMA Call for Issues in 1997-98 also submitted this recommendation.