IMPROVING THE EFFECTIVENESS OF FLOODPLAIN MANAGEMENT IN WESTERN STATE HIGH-RISK AREAS

Alluvial Fans, Mudflows, Mud Floods

Special Publication 9

Natural Hazards Research and Applications Information Center

Proceedings of a Workshop

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OF

FLOODPLAIN MANAGEMENT

IN

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in Palm Springs, California

by

The Association of State Floodplain Managers, Inc.

In cooperation with

The Federal Emergency Management Agency
The California Department of Water Resources

1984

FOREWORD

This two-day workshop was held in Palm Springs, California in February, 1984, to investigate approaches for improving the effectiveness of floodplain management in alluvial fan, mudflow and mud flood areas. The workshop brought together 40 experts from federal agencies, states, local governments, universities and the private sector to address three issues:

- How serious are alluvial fan, mud flood and mudflow problems, in light of overall flood problems in the West, existing development, and future development?
- How adequate are existing maps, regulations, insurance, and other approaches for managing such areas?
- Given limited budgets at all levels of government, how could the states, FEMA, other federal agencies, and communities best improve the effectiveness of management for these areas?

As one might expect, there were differing points of view, yet there was also considerable agreement on major issues. Before the workshop there had been no plan for assembling the proceedings, so papers were not requested from speakers. However, due to the usefulness of the discussion, speakers were asked to prepare summaries; most did. This report contains the speakers' papers and summarizes the discussion.

ACKNOWLEDGMENTS

This workshop is one of several regional meetings held by the Association of State Floodplain Managers to investigate the effectiveness of floodplain management in high-risk areas and to build state, federal and local capability to deal more effectively with such areas. High-risk areas include those subject to mudflows and mud floods, coastal erosion and flooding, ice jam flooding, lake flooding, flooding due to subsidence and liquefaction, as well as areas behind unsafe levees, below unsafe dams, and on and around alluvial fans.

The information gathered, including conclusions and recommendations from this workshop, will be reflected in the report on the entire high-risk study, to be completed at the end of this year.

This workshop was a cooperative effort of the Association of State Floodplain Managers, the Federal Emergency Management Agency, and the State of California Department of Water Resources. It would not have been possible without FEMA's funding support, which is gratefully acknowledged, and the individual efforts of Dale Peterson, FEMA/Region IX; A. Jean Brown, of the California Department of Water Resources; and Jon Kusler, a consultant to the Association. Nor could it have taken place without the enthusiasm of all speakers and participants. Thanks to all.

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EXECUTIVE SUMMARY

I. Workshop attendees generally agreed* that:

A. Alluvial fan and mudflow/mud flood problems are extensive and severe in the West and Southwest and will result in severe future losses due to high growth in these areas. Alluvial fan and mudflow/mud flood problems are extensive (perhaps 20-30% of the total floodplain); such hazards affect a large number of individuals and structures (e.g., 2.6 million people may be at risk from mud/water related phenomena in Los Angeles County); such problems pose a special threat to life and property (5 to 1 or 10 to 1 greater threat to life than clear water flooding); and such hazards are particularly serious in developing and high growth areas such as Marin, Contra Costa, Los Angeles, San Bernardino, Orange, Riverside, Ventura, Santa Barbara, and Imperial Counties in California; Clark County, Nevada; Davis, Salt Lake, and Utah Counties in Utah; Pima and Maricopa Counties in Arizona; and Bernalillo County in New Mexico. Most flood disasters in the West and Southwest have involved a substantial alluvial fan flooding and mudflow/mud flood component.

B. Although some progress has been made in developing mapping and regulatory standards for alluvial fan and mudflood areas, little "on the ground" implementation has taken place. Existing mapping, regulation, and insurance rating approaches developed to address Eastern and Midwestern clear water flood problems understate hazards due to inadequate consideration of velocities, debris, and water-related erosion. Many alluvial fans have been mapped as shallow flood hazard areas, seriously understating the risks they pose. Mapping for mud flood and mudflow areas is less extensive.

C. Despite continued methodological problems for detailed mapping and establishing performance standards for hazard areas, enough is known to take new action now at federal, state, and local levels to better control development in these areas. Given the severe nature of the hazards, the high growth rates and growth potential in these areas, and the increasing threats of legal liability for failure to adequately consider them, immediate and rather simplistic planning, regulatory and insurance-rating approaches should be applied to reduce risk while additional research is conducted on mapping and analytical methodologies, performance guidelines and insurance rating. Such action should be a cooperative federal effort (FEMA, USGS, the Corps, etc.) along with the states and communities. Priority should be given to technical assistance for communities with severe

*See workshop summary and papers. Workshop participant assessments of the magnitude of the problems in particular areas differed.

problems and wishing to carry out planning, regulation and management that exceeds minimum federal, state and local standards.

Workshop attendees expressed disagreement over:

A. Appropriate federal, state and local roles in improving the effectiveness of regulations;

B. The adequacy of existing mapping methods and regulatory criteria for the purpose of requiring state or local regulation; and

C. Specific proposed actions such as reinstitution of the AF Zone for alluvial fans.

II. Workshop attendees suggested certain* immediate and longer-term actions to improve the effectiveness of management:

A. Simultaneous consideration of mapping, regulation and insurance rating. Mapping, regulation, and insurance rating needs should be addressed simultaneously in federal policy-setting and research to help fashion a coherent floodplain management and loss reduction package for particular areas. This may best be accomplished on a multiagency basis and should include hydrologic, geologic and engineering expertise.

B. Better dissemination of existing information. Existing information concerning mapping methodologies, modeling and master planning approaches, and performance standards for buildings and other activities should be better disseminated to FIA map contractors, local governments that want such information, developers and landowners. Such dissemination could take the form of workshops, handbooks, model regulations, one-to-one technical assistance, and video tape presentations.

C. Encouragement for local governments and states to exceed minimum FIA standards. Local governments and states should be encouraged by FEMA and other federal agencies to plan and regulate alluvial fan and mudflow/mud flood areas with standards exceeding those of the National Flood Insurance Program. Such encouragement could take the form of clear policy endorsement by FEMA (Washington and regional offices), technical assistance, training and education, selective mapping, and a community flood insurance rating system giving communities with approaches exceeding minimum FIA standards a preferential insurance rate.

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*See workshop summary and individual papers for more detail.

D. Mapping. Preliminary low-cost mapping is needed for alluvial fan and mudflow/mud flood areas to act as a "red flag" for development problems and so local governments and states could require developers to seek more detailed envineering, hydrologic, and geological analysis and design assistance before receiving a permit. Such preliminary mapping could be based upon historical evidence of flooding or gross parameters (e.g., slope, soil and bedrock type). Such maps are needed for areas with both serious hazards and develoment pressure, constituting only a small portion of the total alluvial fan and mud flood areas. They would include urban and urbanizing areas already mapped by the NFIP without consideration of the special risk factors, areas now being mapped by the NFIP, and additional special hazard areas. The maps could take the form of overlays, eliminating the need to reissue existing maps.

E. Improved performance standards for land uses. Improved performance standards for land uses should be developed by FEMA in cooperation with other federal agencies and the states. Such guidelines should address:

- the preparation and implementation of master plans for alluvial fans and mudflow/mud flood areas; and
- performance standards for buildings and other activities reflecting not only flood depth but also velocities, debris and sediment, and erosion.

Guidelines are needed both for new structures and for retrofitting existing structures. Such guidelines could build upon the experience of several states (Colorado and California) and communities with experience in regulating alluvial fan and mud flood areas.

F. Increases in flood insurance rates. The flood insurance rate structure for alluvial fan areas should be reviewed to determine the true risk. New rates should be based upon preliminary maps where more detailed maps are impractical. Relatively high rates may be appropriate for fans as a whole with the provision that rates will be lowered if the community adopts and implements a master plan reducing flood damages on the fan, or the floodplain occupant designs and constructs buildings consistent with the anticipated velocities, erosion, depths and debris.

The flood insurance rate structure for mudflow/mud flood areas should also be upgraded to reflect actual risk based upon existing maps. However, definitional problems pertaining to mudflow/mud flood versus landslide still need to be resolved before any extensive new mapping effort is undertaken for flood insurance purposes. such broader mapping would, however, be appropriate for land management purposes.

A community rating system that would lower overall flood insurance rates for communities that adopted plans, maps, and regulations exceeding minimum FIA standards for their alluvial fan and mudflow/mud flood areas would also be desirable.

G. Additional problem-oriented research. Additional "problem-oriented" research is needed to improve mapping methodologies for both alluvial fan and mudflow/mud flood areas, develop performance guidelines for building and other activities, prepare standards and techniques for retrofitting existing structures, improve modeling capabilities to assess the nature of risks and the impacts of development, assist communities in preparing master plans, develop and test mitigation strategies other than planning and regulation (e.g., warning systems, dewatering of potential mudflow areas, debris basins, and land treatment after forest fires).

A systematic flood insurance and disaster assistance reporting system is also needed to help identify the full magnitude of alluvial fan and mud flood problems and to test the adequacy of management approaches. Such a system should involve more precise identification more precisely of mud flood and alluvial fan losses and the comparison of disaster assistance and flood insurance data. Field studies should ber conducted after floods to determine the precise nature and types of losses and the adequacy of mitigation approaches.

H. Pilot studies and demonstration projects. Pilot mapping, regulation, and insurance rating studies should be conducted by FEMA in cooperation with other federal agencies (the Corps, the USGS) and the states to test the practicality and feasibility of particular approaches. Such pilot or demonstration projects could also help meet immediate "on the ground" needs if conducted in communities with severe problems such as Clark County, Los Angeles County, Marin and Contra Costa County, and Salt Lake County.

III. Summary:

Workshop participants agreed that alluvial fan and mud flood problems in the fast-growing West and Southwest areas were too serious to delay new management initiatives until all methodological research is completed and detailed maps can be developed. Reasonable additional mitigation actions can and should be under consideration now. Additional problem-oriented research to perfect risk assessment and hazard mitigation methods and techniques should take place simultaneously. FEMA should provide leadership in such efforts, but other federal agencies (USGS, the Corps, SCS, TVA) should privide technical assistance and scientific knowhow. Enhanced state and local roles should be encouraged.

FLOODPLAIN MANAGEMENT AND
UNIQUE HAZARDS IN ARIZONA

Leslie A. Bond, Chief
Non-structural Measures Branch
Arizona Department of Water Resources

During the past year, Arizona suffered disastrous floods in 13 of her 15 counties. Although only a small portion of the damages (which approach $1 billion) resulted from failures in floodplain management, these floods pointed out several of the unique hazards we face. Most experienced floodplain managers realize that these hazards are not really "unique"; they simply lie outside the purview of classical floodplain management procedures.

Most of the problems we have with floodplain mapping and management are related to the movement of solid materials during a flood; aggradation, degradation, braided channels, and channel migration. Landslides, mudflows, and other hazards faced elsewhere have not affected urban development in Arizona.

However, the summer flooding of 1983 on the Colorado River pointed out a problem that has not been addressed in Arizona, and one that is not handled by floodplain management under the National Flood Insurance Program rules: damage resulting from flood-related high water table. Except for the delivery of water to downstream users, the Colorado River has been an ephemeral stream below Hoover Dam since 1929. In 1983, Lake Powell filled for the first time, and there were sustained releases below Hoover Dam of about 40,000 cfs. The actual structural damages caused by these releases were generally the result of poor floodplain management but they were minor. The problem which has a far greater impact is that of high groundwater in large areas adjacent to the Colorado River. In areas with levees adequate to contain the 100-year flood, there are many square miles of land that now have groundwater within a few feet of the surface. Because these areas are outside the 100-year floodplain, our enabling statutes for floodplain management do not apply. The Department of Water Resources is discussing with the Arizona Department of Health Services the possibility of regulating such uses as sewage facilities and landfills in these areas on the basis of water quality.

The Colorado River flood had only a peak discharge with a 10-year to 25-year recurrence interval. It was unexpected from the public standpoint because Lake Meade and Lake Powell have provided almost total flood control for the lower Colorado since 1929. However, since 1978, we have experienced 50-year or larger floods on every other major river in Arizona.

On the Salt River through Phoenix, Arizona, the 100-year flood in 1980 was preceded by 25-year and 50-year floods in 1978. This combination of events caused scour which reduced the 100-year flood elevation by as much as two feet and several square miles of densely developed land was not flooded as forecast by the FIRM. The study of the Salt River used the HEC-2 hydraulic model which assumes a fixed bed. A new study by the Corps of Engineers is using HEC-2 with revised topography. It will provide the profiles and maps for floodplain management until the next major flood, after which a new floodplain management standard will have to be established. In using a fixed-bed model for most streams in Arizona, we are not accurately assessing the elevation and areal extent of the event which has a one percent chance of being equalled or exceeded in a given year.

That same series of floods caused deposition of material downstream in the Gila River. A dense stand of salt cedars along the thalweg of the Gila River slowed the floodwater in the 1978 floods, causing deposition of as much as 12 feet. The 1980 flood cut new channels through agricultural land in the floodplain, moving the main channel of the Gila River as much as a mile laterally. A project is underway to remove the salt cedars and put the channel back to its approximate 1978 location.

The October 1983 floods gave us new reason to examine channel migration. Problems had been observed in the 1980 flood on the Agua Fria River where the channel migrated at least 200 feet in the Black Canyon city area. Near Tucson, Arizona, the channels of the Santa Cruz River and Rillito River are sufficiently incised to contain the 100-year flood. In many reaches, the banks are stabilized. However, channel migration caused serious problems for some structures that were not within the delineated 100-year floodplain. Pima County and Tucson have regulations requiring a setback from streambanks, but I am concerned that the courts might say that they exceed their statutory authority where these setbacks are outside the 100-year floodplain.

The October 1983 flood also provided evidence of sheet flooding in areas where there is essentially no channel. Fifty or sixty miles of the Santa Cruz River in Pinal County was flooded to widths as great as eight miles. The U.S. Geological Survey does not even show the location of the Santa Cruz River on its maps because there is no single channel. A building code could easily reduce flood damage in an area like this, but mapping is almost impossible. Any continuous obstruction, such as highways, dense crops, or irrigation canals, causes dramatic changes in the depth and location of a flood of this type. Such obstructions are usually not regulated, and their impact is almost impossible to assess until a major flood occurs.

This problem is not dissimilar to the shallow flooding on the lower portions of alluvial fans and other distributary systems. There are many alluvial fans in the rapidly urbanizing areas of Maricopa and Pima counties. In many of these, the incised and meandering portions of the fans are federal and state land, and only the sheet flow areas are subject to imminent development. This situation also exists in Cochise, Pinal and Yuma counties, although the development pressure is not as great.

Our worst alluvial fan problems are along the Colorado River in La Paz and Mohave counties where many alluvial fans are truncated by the Colorado River. In Mohave County, the Federal Emergency Management

Agency (FEMA), over the objections of the state and the county, mapped alluvial channels as AO Zones with depths up to five feet and velocities of 11 feet per second. AO Zones, according to the FEMA definition, have depths of only one to three feet. Mohave County asked that the entire width of the channels be designated as "floodway", which a community can do in a riverine situation. However, since FEMA had already designated them as AO Zones, they would not map a floodway.

All flood waters in Arizona streams are loaded with sediment. In Clifton, Arizona, the October 1983 flood left four feet of sediment in houses that were flooded with eight feet of water.

An underlying factor that aggravated all of our problems in floodplain management is the rapid rate of development in Arizona. This has three negative aspects. First, our communities' maps are always out of date because of the constant expansion of corporate limits. Second, the flood insurance study process takes so long that by the time a study is completed, new development has gone beyond the areas studied. Third, this development alters the hydrology and hydraulics to such an extent that downstream studies are inaccurate. Our more sophisticated communities require developers to produce studies and minimize the effect of their activities, but many communities do not have the technical capability to review such studies.

Magnitude of Unique Flood Problems in Arizona

Problem	Areal Extent	Number of Structures
Water table	20,000 acres	3,000
Aggradation/ degradation	thousands of miles of channel	hundreds
Channel migration	100 miles of channel	hundreds
Sheet flooding	tens of thousands of acres	thousands
Alluvial fans and distributary systems	thousands of acres	hundreds
Rapid development	thousands of acres per year	thousands per year

(Estimates are within an order of magnitude.)

Special Mapping and Regulation

Problem	Current Solutions
Water table	Drainage wells in most highly impacted areas.
Aggradation/ degradation	New fixed-bed model studies, some structural measures (drop structures, channel clearing).
Channel migration	Local regulations, structural measures.
Sheet flooding	None
Alluvial fans and distributary systems	None
Rapid development	Local regulations on new development in some communities.

Problems with Existing Approaches

The existing studies and maps do not accurately forecast the extent or depth of flooding and flood-related problems, either for present conditions or for the future. Development standards that can be applied by a small community with limited technical capabilities are unavailable. Structural solutions, where applicable, are prohibitively expensive as an alternative to proper land-use planning. Flood insurance maps are usually out of date due to changes in corporate limits, modified runoff characteristics and new development in unmapped areas.

Plans for Strengthened Approaches

Current budget constraints limit the state's ability to implement any innovative or progressive measures. Proposed legislation may enable the Arizona Department of Water Resources to look for innovation in floodplain management and mapping, but lack of funding will almost certainly forestall any real progress. Since these problems are not unique to Arizona, it is difficult to promote a unilateral solution in the face of scarce state resources.

Federal Agency Response

I think it is important to remember how far we have come, and how we got here. In the last 15 years, tremendous progress has been made toward "A Unified Approach to Floodplain Management." According to FEMA, some 8,000 communities have flood insurance rate maps, the only maps which are really useful for floodplain management. Another 2,000 studies are underway. The total expenditures for mapping since 1969 are just over $600 million. These studies are a terrific national asset. Aside from their use by communities for floodplain management, they provide topographic mapping and hydrology which can be used for a wide range of purposes, such as the design of bridges and other public facilities. However, floodplain management may well be the only discipline that allows no safety factor. We begin with an inadequate data base, apply generalized stochastic methods to it, run the results through empirically derived models whose parameters we cannot accurately measure, run those results through another model whose basic assumptions are grossly violated and then use the results to regulate to 1/100th of a foot. Just using the upper 95 percent confidence limit on the 100-year quantity of flow would (in Arizona) increase it by 50 percent to 200 percent in most cases.

Recommendations

A major change that is required is a separation of mapping for insurance purposes and mapping for management. Insurance rates must be based on current conditions and current risks. To maintain the same acceptable level of risk in the future, management must consider future conditions.

A renewed mapping effort is needed in Arizona and other rapidly developing states. Arizona's population has increased 70 percent since the flood insurance studies began in 1969, and it is expected to almost double in the next 25 years. If floodplain mapping is not done ahead of this growth, the potential for future damages is great.

Mapping should be produced on a county-wide basis and revised as needed for both floodplain changes and changes in corporate limits of communities. Revisions should be made on a sheet-by-sheet basis as needed.

Finally, an all-out research program is needed to develop methods for forecasting sediment transport and its impacts on floodplain management: aggradation, degradation, channel migration and the behavior of alluvial fans and other distributary systems. The cost of these studies is dwarfed by the potential damage if they are not done.

Despite the weaknesses I have mentioned in Arizona's floodplain management program, we are still far ahead of the national actuarial experience in insured structures. Through 1981, insurance claims in Arizona totalled only 63 percent of the premiums paid. In fact, the total deficit in the National Flood Insurance Program is less than the deficit for three Gulf Coast states. The insurance rate zones where the highest actuarial losses have been experienced are: unnumbered A Zones, where detailed studies were not done; B Zones, where flooding should be shallow and infrequent; C Zones, which are supposed to be free of flooding; D Zones, which have not been studied; and A99 Zones, where structural measures are supposed to provide protection (see Table 1). All of these have a higher loss ratio than numbered A Zones and numbered V Zones. This tells me that the way to an actuarial flood insurance program and reduced damages is through better mapping rather than higher premiums.

TABLE 1

NATIONAL FLOOD INSURANCE PROGRAM
ACTUARIAL EXPERIENCE

JANUARY 1, 1978 - DECEMBER 31, 1981

ZONE	A1 - A30 PRE-FIRM	A1 - A30 POST-FIRM	U1 - U30 PRE-FIRM	U1 - U30 POST-FIRM	UNNUMBERED A	AO AH	B	C	D	A99	EMERGENCY PROGRAM
$ LOSS / $ PREMIUM	1.45	0.80	1.09	1.61	1.67	0.39	1.89	2.87	1.30	1.18	2.26

NOTE: IN THIS TABLE, 1.00 WOULD BE "ACTUARIALLY SOUND", NOT COUNTING OPERATING EXPENSES.
A VALUE LESS THAN 1.00 INDICATES A PROGRAM "PROFIT", WHILE A VALUE GREATER THAN 1.00 INDICATES A PROGRAM "LOSS".

UNIQUE HAZARDS IN NEVADA

Susan A. Santarcangelo
Flood Mitigation Officer
Division of Emergency Management
State of Nevada

Extent of "Unique" Hazards in Nevada

The federal government owns approximately 80% of the land within the state's boundaries. This drastically limits the area available for farming, mining and housing. Most, if not all, of the land that is available for development is affected by one "unique" hazard or another. Virtually all of Nevada's land is susceptible to some degree of alluvial fan flooding. The mountain ranges that cross the state create wide fan aprons that coalesce in the valley floors. These aprons are often cemented or covered with "desert pavement", a natural, nearly impermeable covering. Even relatively minor rain can result in sheet flow. When larger thunderstorms (or rapidly melting snow) accumulate water in high canyons, these waters often coalesce in upstream drainages emptying into the fan through relatively narrow canyons at the fan apex. This water is often laden with sediment and debris.

A joint project between the U.S. Geological Survey and the Nevada Division of Mines and Geology mapped some of the more dangerous mud and debris flow areas in the more quickly developing counties. These maps show potential hazards in the North Lake Tahoe, Washoe Valley (Reno) and Clark County (Las Vegas) areas. Many of the most dangerous zones are also the most desirable for development because of their scenic nature. A recent debris flow on Ophir Creek in Washoe Valley destroyed five homes and damaged a number of others (there was also one life lost). This area was mapped by FEMA as an unnumbered A Zone. Because no one in the area had flood insurance, and the flow was created by an avalanche-landslide moving into a storage reservoir, the incident was termed an avalanche so that people could file other insurance claims. Thus, the damages are not reflected in the NFIP damage figures, even though the incident was a direct result of a debris-laden wall of water. This land had been mapped as a debris/mud flow area by the USGS and maps published by the Nevada Division of Mines & Geology in 1977, but had not been delineated on the FIRMs for Washoe County, which are still in the preliminary stage.

About 75-90% of the developable land in the state is susceptible to alluvial fan flooding of varying severities, depending on the size of the watershed and the length of the fan. The sediment load depends also upon the size of the watershed and the velocity of the water. Mud/debris flows are a normal by-product of alluvial fan flooding.

Nevada is less susceptible to the type of mudslides that occur frequently in California. This type of slide, which results from saturation of unstable materials resting on a slope, occurs in some of the high mountainous areas and where slopes have been improperly excavated. These are not very common in Nevada.

In the north and northeastern section of the state, where perennial river systems exist, portions of these systems are affected by clearwater flooding. However, most of the systems have large sections more aptly described by aggradation-degradation models.

Major Problems with the FEMA Approach

FEMA's seeming unwillingness to recognize these problems on the national level because they are not reflected in the insurance figures, is distressing. It is obvious that the regional officers see the problem, and in many cases, have taken the lead in trying to convince headquarters that it exists.

Under the sanctions of the NFIP, FEMA has made it possible for many communities to perform floodplain management even though it may be politically unpopular. Their further backing through recognition and development of mitigation programs for unique problems can be extremely helpful as a political tool to aid the floodplain management efforts of communities. We often need to have that federal "scapegoat" in order to get things accomplished. When dealing with multi-million dollar programs, it is easier to say that it must be done because "the feds require it" than to say that the local public works department requires it. FEMA should allow the regional offices to help us identify our special problems and then back us up in dealing with them.

Recommendations

- FEMA should leave more power for dealing with regional problems in the regional office.

- FEMA should establish the goals they wish met within the program, then allow the regions and the states to define how best to reach those goals. This would include identification and definition of "unique" hazards for the area and methods of incorporating those data into the existing mapping format.

- Mapping formats should be more flexible so that data useful in a particular area can be incorporated easily. Such information as regional topography may be unnecessary and confusing in highly developed areas, yet it may be critical for interpretation and use of the maps in less developed ones.

- FEMA should not try to be the sole technical advisor. It should identify the basic problems it would like to see addressed, then assist communities to find other governmental agencies with the technical capabilities to deal with the problems or allow them to seek outside technical assistance. The variety of problems throughout the United States is too wide and varied for FEMA to address without a much larger technical staff, which would duplicate efforts of many agencies. FEMA should coordinate, not duplicate.

- FEMA should provide more technical assistance by sponsoring workshops or classes (taught by experts practicing in the fields) on the technical aspects of regional "unique" hazards. This is a perfect opportunity for FEMA to encourage the participation of such other technically oriented agencies as USGS and the Corps of Engineers, as well as persons from the private sector.

UNIQUE HAZARDS IN OREGON

Carl L. Cook, Jr.
Flood Project Manager
Department of Land Conservation and Development
State of Oregon

High Risk Areas in Oregon

While that portion of Oregon east of the Cascade Range has alluvial fan formations, rarely has anyone attempted to develop on them. In one or two instances where fan flooding potential has been delineated, it has been done without fanfare. I know of no instances in Oregon where a city or other concentration of development has been placed on a hazardous alluvial fan.

Canyon flooding, which has severely affected such areas as the Moses Coulee in Washington, many areas of Nevada, and a number of communities in Idaho, rarely visits Oregon. If it does, it occurs in regions of the state that are so sparsely populated that no structural damage is done and no observations are made. Debris-bearing flows are noted in Oregon with about the same infrequency.

Ice jam flooding does occur in eastern Oregon just about as frequently as it does in Idaho and Washington. However, in Oregon there is much less development in the areas subject to this type of occurrence. Eastern Idaho's major cities of Idaho Falls, Blackfoot, and Pocatello are all subject to ice jam flooding from major rivers.

While Oregon has fewer "unique" hazard problems than the other statesin Region X, the entire region suffers from these hazards to a much lesser extent than do the other western states. Whereas 80% to 90% of Oregon problems are caused by "clearwater flooding", representatives from California, Nevada and Arizona indicate that it may cause the majority of their problems. While most Oregon cities are located on rivers, they are developed in a manner that minimizes their damage potential. This can partially be attributed to the fact that there is ample non-hazard land to develop and that the land use planning process is fairly well advanced in Oregon.

NFIP insurance claims can be used as an indicator of the extent of Oregon's "unique" hazards. From 1978 to 1983, there were 635 claims paid in the state. Of those, five or six may have been caused by "unique" hazards—less than one percent. Though the hazardous land area affected by all "unique" hazards may be as high as 5% to 10%, the large majority of these areas is undeveloped. A good estimate might be that on a regional scale the proportion is the same, except that Idaho may go as high as 20%.

Since most development in Oregon's floodplains occurred prior to the constraints of the NFIP and the state planning statutes, the potential for growth in these hazard areas is relatively minimal. This is particularly true regarding the "unique" hazard areas. A steady decline in the percentage of total floodplain development that represents that portion built in "unique" hazard areas can be expected.

Mapping High Risk Areas

The major problem in mapping the "unique" hazards is that their nature makes them difficult to treat uniformly. The standard backwater analysis used in riverine cases can be routinely used on most US rivers with satisfactory results. However, FEMA's method for alluvial fan flooding delineation is claimed not to produce consistently realistic results. What is satisfactory in Wenatchee is overkill in Boise and insufficient in Rancho Mirage. While Oregon and Region X floodplain managers support the generation of a mapping method to handle the very severe fan flooding experienced in the southwest, it is questionable whether such a method should be extended to Region X states. We do support the formation of a separate zone designation for fan flooding (e.g., AF). However, we would hope that regional, state, and study contractor discretion could be exercised in its application. For instance, on fans experiencing very low slope gradients, shallow flood depths, and little velocity hazard, the present A-O Zone designation is sufficient.

This principle holds true in the arena of regulation as well. While strict regulatory constraints are commensurate with the hazards of Rancho Mirage, Palm Desert, and many other Utah, Arizona and southern California communities, they may be much too severe for floodplains in the northwest. The present NFIP regulations are sufficiently matched with the severity of hazards in Oregon. Change may be appropriate for the floodway section of the NFIP regulations, however. Even there, the existing floodway concept is reasonably applicable for the majority of cases. In some instances alternatives to the equal conveyance floodway are more appropriate. FEMA has been reluctant to recognize these for fear of setting unwieldly precedents. Though this issue is more pertinent to riverine cases where density criteria might be considered, the alternative floodway question applies to the alluvial fans also.

Generally speaking, the monetary worth of development that might be placed in Oregon's "unique" hazard areas is not great enough to warrant the large funding outlays necessary for structural solutions. While the Coachella Valley residents can afford to protect their development with structural projects that may cost each individual several thousand dollars, that is not the case in Oregon.

Problems With Current Approaches

The mapping approaches used by the federal agencies generally match their level of involvement in floodplain management. However, the agencies are constrained by the need to use methods that are nationally standardized. Local and state agencies are more free to adopt advanced mapping methods. While FEMA has been unable to recognize future development in its flood mapping, communities in several areas of the country are now doing so. The local and state governments likely will be the vanguard of floodplain mapping, especially of "unique" hazards, since they are not constrained by the universal applicability standard.

Again, the same principle holds true for regulation. Now that most substantially affected communities have adopted floodplain ordinances and have become familiar with accepted management principles, more communities are tailoring their programs to meet their individual needs. For instance, in older, highly developed communities, control of urban drainage has a greater consequence than does enforcement of a FEMA ordinance. In all probability there is little new development proposed for such floodplain land, so that the ordinance sees little use. At the same time, uncontrolled development outside the floodplain (and therefore not governed by the ordinance) may be steadily increasing the flood potential via increased runoff.

The present direction of the insurance arm of the NFIP will help the management aspects in the long run. While it is sometimes distasteful in the short-term, the declining subsidization of the NFIP will work towards minimizing floodplain development.

CLARK COUNTY UNIQUE HAZARDS

Dennis Bechtel
Principal Planner
Clark County, Nevada

Extent of "Unique" Hazard Problems

The Las Vegas metropolitan area is located in a valley entirely ringed by alluvial fans. Most of Las Vegas' flood-producing storms are generated on the slopes of these alluvial fans. Because of their extent, the rapid growth of the metropolitan region (the population is expected to double by the year 2000) and the fact that growth is expanding into alluvial fan areas, current flooding hazards will undoubtedly increase unless remedial actions are taken.

Principal Advantages and/or Problems with Existing Approaches

The major problem faced by Clark County is the fact that alluvial fan flooding has not been addressed adequately in the flood insurance program. Although we are fortunate in the sense that FEMA is requiring an alluvial fan analysis in Clark County's restudy, there still does not appear to be a great deal of guidance from FEMA to its study contractor relative to the mechanics of the analysis. Without examination of the alluvial fan flooding, problem areas will be greatly understated on the final maps.

Another major weakness in the program is its failure to consider sediment as a component of total discharge in evaluating the hydraulics of flooding. In the Southwest, sediment transport constitutes an important element of flood flows and, if not analyzed, can create misleading figures on flood discharges and elevation.

There also is a need for FEMA to require closer cooperation between the study contractor and the locale being studied. Coordination has often been perfunctory (although in Clark County's restudy the cooperation has been good). Having local engineers and planners become part of the process as it develops will permit them to better understand their own problems. This will undoubtedly assist FEMA greatly in the future. Likewise, requiring close coordination ensures that potentially valuable local information and insight are not overlooked.

Recommendations

General

- Rather than being national in scope, FEMA's regulations should be more sensitive to regional differences. For example, alluvial fan flooding is almost entirely a phenomenon of the West. By not considering local flooding situations such as these, the maps and other information provided by FEMA can become highly misleading.

- FEMA should require close cooperation between the study contractor performing the work and the community that will have to live with the maps and translate them to the public. Having available the tools (discharge models, for example) and information generated from the study can help a community plan its stormwater management. This will also assist FEMA in future map revisions.

- To ensure that a community fully understands the processes involved in developing the floodplain maps, local planners and engineers should be afforded the opportunity to work with the study contractor or "train" with the tools available. The community will thereby gain valuable experience in using the models.

- In addition to the alluvial fan flooding, other regional differences often are not taken into consideration in floodplain studies. One example is rainfall distribution. In the Southwest, flood-producing storms are often the result of small, localized convectional storms rather than the area-wide frontal storms so common in the east. The computed discharges can be altered dramatically by using the eastern method in a western setting (as was the case in the original Clark County study). Regulations should be sensitive to these regional differences.

Floodplain Mapping

- Too often several communities are part of the same hydrologic regime, yet individual maps do not include information from adjoining communities. It would be more useful to produce maps by hydrologic basin that would include all needed information. It is obviously important for planning purposes to know what is going on in surrounding areas since that can greatly influence development decisions. Maps generated by hydrologic basin and not by political boundary will facilitate review and ensure that nothing important is missed.

- Maps produced by FEMA should be usable. The current blueline FIRM maps are often less than ideal for classifying development by floodplain elevation. Since most studies now include aerial photographic work, it would be useful of the contours and floodplain delineations were placed on aerial photographs. These would provide an infinite number of reference points and would facilitate the ability to properly classify development into flood hazard zones. The expense would be slightly greater but it would make the maps more valuable.

Alluvial Fans (AF)

- The AF floodplain zone classification should be reinstituted. The AF zone should include a floodway designator (in an area of active alluvial flooding) that would enable a community to preclude development from these potentially dangerous areas. The current AF zone of shallow flooding is imprecise and does not permit floodway designators.

SUMMARY REMARKS

William H. Longenecker, Jr.
Deputy Chief Engineer
Coachella Valley Water District

Tropical Storm Kathleen hit Palm Desert and other communities on the west side of the Coachella Valley, California, in September 1976, causing tens of millions of dollars in damage. Within two days, representatives from one of the biggest and best engineering firms in the world, Bechtel in San Francisco, arrived to begin designing a system to protect Palm Desert, Indian Wells and Rancho Mirage from a similar occurrence.

At public meetings in October 1976, Colonel Robinson of the Corps of Engineers reported that, if everything went perfectly it would be fifteen years before the first shovel of dirt would be turned. Three months later, Bechtel reported back with fifteen alternatives to protect Indian Wells, Palm Desert and Rancho Mirage, ranging in cost from $16 million to $21 million. Bechtel narrowed these down to one recommendation by August 1977. It then carried the approved recommendation out to final design.

When Tropical Storm Delores caused similar devastation to the same areas in July 1979, the people of the Cove Communities knew they could not wait for a federal solution. In February 1981 a small group of interested persons met to discuss building flood control works with local money. The culmination of those efforts was the formation of a redevelopment agency and the sale of bonds to finance the project. Now, the project is completed and is an example of local financing and local control producing results in just three years—one-fifth of the time it would have taken to untangle the federal red tape.

The importance of cutting twelve years off the completion time has already been seen. Before the project was finished, it prevented what could very well have been a recurrence of the damage caused by Storms Kathleen and Delores when, in August 1983, it carried most of the heavy flows from Tropical Storm Ismael safely around homes and businesses in Palm Desert. Most cities and counties, including Palm Desert, have floodwater ordinances requiring protection from the 100-year flood. Palm Desert now has protection from a "standard project flood"—in Coachella Valley this is defined as a 250-year to 350-year storm.

The City of Rancho Mirage, taking its cue from Palm Desert, did exactly the same thing. It formed a redevelopment agency to finance the construction of stormwater facilities. In March 1984, the final inspection was made of three stormwater projects in Rancho Mirage. One major project there remains undone. This is the West Magnesia Stormwater Channel, a Corps of Engineers project. The impetus for this project was provided after the July 1979, storm when the Coachella Valley Water District formally requested the Corps to undertake a study under Section 205 of the Flood Control Act of 1948. In December 1982, the Corps issued a draft detailed project report and the EIS. The final report should be sent out by the Los Angeles office by the end of March 1984.

The Palm Valley Stormwater Channel is designed to carry 28,000 cubic feet per second safely to the Whitewater River Stormwater Channel. The project required solution of some complex design problems. The channel drops 800 feet in five miles with a steep slope, averaging 4%, above Highway 111 and a much flatter slope below the highway. With this kind of slope, flows are expected to reach velocities of 70 feet per second, nearly 48 miles per hour. To check the designs, a scale model was built of the channel and flow tested. Not very many companies provide this type of testing service: we had to go to British Columbia to have it done.

Construction Cost

Stormwater Channels

Palm Valley	$13,400,000
Villas	2,400,000
Peterson	1,100,000
East Magnesia	1,100,000
Thunderbird	400,000
La Quinta System (not constructed, estimated)	13,000,000

SUMMARY REMARKS

Kenneth L. Edwards
Chief Engineer

David T. Sheldon
Planning Engineer

Riverside County Flood Control and
Water Conservation District

There is not much concern with mud flow or mudslide hazards in western Riverside County, California. Alluvial fan problems are, however, becoming a greater concern as development progresses from the coastal valleys into steeper terrain and eastward into the desert. Virtually all future desert development will take place on recent alluvium. Damage will still occur in the "conventional" riverine valleys until remedial flood control facilities are constructed.

The following suggestions are ideas for improving flood management problems in high hazard areas.

- Establish appropriate building standards in AO (depth) (velocity) zones. For example; floodproofing heights should be greater than the depth of the unimpeded flow. Any substantial obstruction will cause velocity head to translate to an increase in depth. These decreased velocities often cause localized aggradation and result in further increases in flood depth. Floating debris aggravates the problem.

  Current regulations consider velocity only by citing 10 fps as a standard by which floodways may be differentiated from flood plains. Erosion should be recognized as a velocity-induced hazard to development. Velocity should be considered one parameter by which scour and hence scour protection requirements can be established.

  Velocity might be considered along with depth as an indication of hazard. A numerical product of the two, i.e., (depth) x (velocity), equal to 10 has been considered hazardous to life. Other values might be established as indicators of a site's development potential, e.g., 20--vehicles will move, no recreational vehicle parks; 30--streets move, no development.

Guidelines should be developed that address the density of develpment in AO Zones. Floodproofing becomes meaningless if the entire width of the flood plain is developed regardless of how high structures are elevated. These guidelines should recognize both the case in which individual buildings are protected with open areas between and the case where a number of buildings are floodproofed as a unit and flood flows are diverted around the entire development. Density standards should address both new development and areas that have been subdivided into small lots, but not yet substantially developed. If in the latter case certain lots need to be declared unbuildable, specific legislation should be enacted to prevent courts from ruling that local agencies had exceeded their statutory authority.

Disaster relief grants and loans might be reduced if development standards recognized the damage potential to infrastructure in high velocity areas. Roads and utilities can sustain substantial damage in some areas. We have seen a condominium development (.5 to 2.5 million dollars per unit) become isolated when an admittedly inadequate stream crossing was obliterated.

- Allow, with local concurrence, floodplain mapping consultants to exceed federal mapping standards by using more advanced hydraulic analysis techniques such as moveable bedmodels that would predict otherwise undetectable stream breakouts and channel migration.

- Require the states to comply with the same federal standards as the local governments.

- Improve the availability of both FIRM and floodway maps to local private interests.

OCCURRENCE OF UNIQUE HAZARDS IN SAN DIEGO

Joseph C. Hill
Principal Civil Engineer
County of San Diego
Department of Public Works

Special clearwater flood hazards are extensive in San Diego County. They can be separated into two categories.

Erosion and Sedimentation in Rivers

In some locations river beds are subject to extreme change during flood conditions. Lateral erosion during flooding can move a river several hundred feet outside the bank of a floodplain that has been defined with clearwater analytical methods. Sedimentation can raise a river bed--and the floodplain level--many feet above and beyond the clearwater floodplain. The percentage of river lengths affected by major erosion and/or sedimentation is 10% to 20% in San Diego. While the percentage of river lengths is not great, the effect on property is. There are documented cases in which floods of 10-year to 50-year recurrence intervals have damaged structures and property outside existing floodplain boundaries.

Alluvial Fans

Alluvial fans are a major hazard in the desert area of San Diego. The desert covers the eastern quarter of the county. The hazards are very similar to those in Palm Springs. Existing houses and facilities have been damaged in recent years by torrential rain and flood flows resulting from tropical storms and intense desert cloud bursts. Additional development is tending to move farther up alluvial fans, exposing people to greater hazards.

Problems with Existing FEMA, State and Local Floodplain Management

Background

San Diego County relies on floodplain management as the only means of flood control for virtually all major rivers and streams. The County initiated a floodplain mapping and planning program prior to implementation of the National Flood Insurance Program (NFIP). As federal funds became available the two programs were coordinated so that criteria and floodplain studies are compatible. The programs were also coordinated with the cities. The following table provides a list of organizations that have participated in producing about 240 miles of detailed flood studies currently used for planning and regulation of development.

Corps of Engineers	90 miles
State of California, Dept. of Water Resources	20 miles
County of San Diego	130 miles

(The County provided orthophoto base maps, digitized cross-sections and plotting of floodplain lines for all the detailed floodplain studies.)

Experience has shown that detailed flood studies are essential if floodplain management is to be implemented in areas with high property values. Since enforcement of the floodway has a big impact on property values the quality of studies is important. Criteria used in San Diego floodplain studies are:

- Orthophoto base maps (1 inch = 200 feet). These maps have a photographic quality which provides an effective basis for locating floodplain and floodway lines.

- Digitized cross-sections. The accuracy of digitized points is better than one foot. Up to 99 can be used per cross-section to provide a sufficient basis for development regulation.

- Floodways have specific boundaries. The floodway can be tied to the California coordinate system and property lines.

Even with high-quality floodplain studies considerable opposition from property owners was experienced in the implementation of floodplain maps.

Specific Problems

- FEMA floodway studies do not identify floodway lines with specific location that can be defended with a good quality cross-section and computation. Digitizing and plotting costs about $1,000 per mile, a small part of the total floodplain cost. FEMA could provide much better studies with only minor increases in cost.

- The impact of major erosion and sedimentation in rivers and streams is not recognized in FEMA studies. The National Academy of Sciences evaluated erodible bed models as a method of predicting changes to rivers during floods. The report includes a recommendation that erosion/sedimentation analyses be used in rivers that are disturbed (not in natural equilibrium) and likely to experience major streambed changes.

- The use of floodplain and floodway studies for planning and regulation purposes tends to be neglected. It is difficult for a local government to effectively file and update the extensive data needed for regulation of development in floodplains.

Recommendations for Improved Approaches to Floodplain Management

- Recognize the economic benefit of using floodplain management to avoid the need for construction of channels. Floodplain mapping costs $5,000 to $10,000 per mile while channel projects cost $1 million to $20 million per mile.

- Provide floodplain and floodway maps with sufficient quality so that they are usable for regulation of development.

- Include the significant effects of erosion and sedimentation.

- Provide incentive for good floodplain management by local government through reduced flood insurance rates and support for local floodplain programs.

UNIQUE HAZARDS IN LOS ANGELES COUNTY

Carl L. Blum
Division Engineer
Los Angeles County Flood Control District

Extent of Hazard

Of the 7 million people who live in Los Angeles County, approximately 2.6 million live in areas that could be affected by mud hazards. The population of this area increased approximately 7% from 1970 to 1980. Since the easily developable land has been almost fully utilized, the development taking place now in Los Angeles County is primarily in the foothills or other areas subject to various hazards. As a result, it is critical that the unique hazards be adequately identified so that those responsible for development regulation can assure the public safety of this increasing population.

Los Angeles County has approximately 4,080 square miles of which 2,060 square miles are debris-producing watersheds and 2,020 square miles are valley or flatlands. Of the debris-producing watershed areas, 560 square miles are subject to mud hazards and should be mapped. Of this, 370 square miles are subject to mud flows and mudslides. The remaining 1,130 square miles of this are are either included in a national forest or are remote from development activities. Some of this area is on the northside/desert side of the mountains that surround the Los Angeles basin. Although there is relatively little development in much of this area at present, it will probably be developed as pressure for more housing increases. In addition, the county has 250 linear miles of foothills that are subject to alluvial fan flooding. It is obviously desirable to have hazards identified before any development takes place.

Of the 80 communities in Los Angeles County for which clearwater studies have been completed, 28 are affected by mud hazards. Because the engineering staffs and the political bodies which control development in these communities often do not have the expertise or the dollars to identify the mud hazards, they allow development to take place in high hazard areas without adequate safeguards.

The 1978 and 1980 flood disasters in southern California demonstrated that a majority of flood damage is often caused by mud. It is estimated that the total damages to public and private facilities caused by mud hazards during these two disasters exceeded $100 million.

Mapping

The existing clearwater mapping has been a good start toward identifying hazard in Los Angeles County. However, it is only a start because of critical deficiencies in the method used to prepare the clearwater maps.

- The method does not consider debris (since many of our flooding problems are related to debris and the movement of debris with the storm waters, in many cases the existing method significantly under-estimates the amount of flow expected during major storms).

- It does not consider future development but only accounts for development that presently exists (much of the risk to existing development in Los Angeles County is caused by development of the upstream watershed). Upstream development decreases the amount of permeable land surface and increases the time of concentration of the runoff. The result is often a significant increase in the peak volume of even the clearwater flows.

Because these two factors are not considered in the standard clearwater method, the maps have had a somewhat misleading effect on planners and politicians in the area. There has been a push to use the federal mapping standards rather than the local standards, which take into account future development and debris. This has resulted in the nationwide criteria being used as evidence against local standards rather than as support to help local communities identify their real hazards.

Another effect of having clearwater flood insurance maps is that some communities subject to mud hazards have a false sense of security because they see on the clearwater maps that no significant hazard exists.

A major problem is obtaining a mud hazard mapping method that is acceptable to FEMA. It is necessary to identify the mud hazards in the southwestern United States as unique to that area and develop a method applicable there and not try to find one to address every situation across the entire United States. A team of experts (FEMA, USGS, Corps of Engineers) needs to be assembled, and armed with the best information to develop an acceptable method as soon as possible. This method needs to be broad enough to allow easy implementation. If it is a very detailed method requiring detailed mapping, which requires detailed topographic information, there may never be enough money or time to implement it.

There appear to be two goals for a mapping program. The first is to provide guidance for development regulation and the second is to identify hazards for rate setting in an insurance program. We should separate these and address them in parallel and not hold up providing hazard maps for development regulation purposes until all the details of an insurance program are worked out. In Los Angeles County we have been working with FEMA for over five and a half years trying to get mud hazard maps published. Development is occurring and will continue to occur whether we provide hazard identification guidance or not. If we do not, we are only allowing areas of potential disasters to develop for which the federal government will be asked, in later years, to spend millions of dollars on disaster assistance for the community.

FEMA also needs to provide some muscle/incentive to encourage communities to enforce effective floodplain management programs. Whether the incentives are admission into the insurance program, possibly at a discount rate, or the muscle be the withholding of disaster funding or some other method, should be explored by FEMA.

SUMMARY REMARKS

Benjamin Roberts, Vice President
Anderson-Nichols & Co., Inc.

This summary will present (1) the breadth and prevalence of special hazards based on Anderson-Nichols' experience; (2) a brief description of Anderson-Nichols' study "Flood Plain Management Tools for Alluvial Fans"; (3) conclusions about existing hazard delineation methods; and (4) recommendations for further efforts to improve hazard delineation and mitigation.

Prevalence of Special Hazards

During our work on flood mitigation on alluvial fans, we identified several dozen urbanized or developing areas in which flooding on alluvial fans and/or aprons has resulted in significant damages. These affected areas were found in all parts of the West and as far east as Texas. Although hydrologic conditions varied substantially from one location to another, high velocities, unpredictable flow paths and sediment transport were common hazards at all locations. A study by the U.S. Army Natick Lab identified over 3,800 alluvial fans within a 19,500 square mile area of the southwestern United States and estimated that over 30% of American southwest deserts are occupied by alluvial fans. Given the occurrence of fans, aprons and washes and the rapid development of the Southwest, a substantial escalation in the number and severity of damaging floods on these formations is likely.

Description of Alluvial Fan Study

Anderson-Nichols was authorized by FEMA to study flood behavior, flood hazards, hazard mitigation and floodplain management on alluvial fans. This study included a summary of the current state of the art in flood hazard analysis and mitigation on fans, case studies of actual damaging flood events, physical modeling of flood processes and mitigation measures, evaluation of hazard mitigation techniques, and development of general floodplain management guidelines. The following is a very brief summary of the most important conclusions of that study.

Fan and watershed characteristics that strongly affect hydraulics and sediment transport should be identified and evaluated during the process of predicting flood hazards. These characteristics include such watershed conditions as slope, soil type, and vegetation, and such fan characteristic as slope, shape, existence of entrenched channels, and sediment type.

The dynamics of flooding on fans are extremely complex, with rapidly changing flow paths and behavior that vary from one fan to another. Certain commonalities in flood behavior can be seen, including the existence of several hydraulic zones with distinctly different flow conditions, the dependence of flood behavior on fan and watershed conditions, and the importance of considering both the geologic time scale and a human time scale during flood management.

The following flood hazards are of significant importance on fans: inundation, sediment deposition, scour and undermining, impact forces, hydrostatic and buoyant forces, and high velocities. Relationships between hazard severity and watershed and fan characteristics were developed during the study and can be used in assessing the potential for damaging flood events. However, the use of a simple, uniform method of hazard identification may not adequately define flood conditions or potential damages.

Equations that relate key flow variables to fan characteristics were developed and tested during the study. Such relations are potentially useful tools for predicting flood hazards and are a potential alternative to more simplistic methods.

A number of flood mitigation tools were tested in the physical models, including debris basins, levees, channels, drop structures, local dikes, street orientation and design, and elevation of structures. "Whole fan" measures, such as debris basins and channels, are necessary when extensive development precludes localized protection. Local dikes and street design can be used to protect isolated subdivisions or when all the development on a fan is coordinated and is of low to moderate density. Elevation of structures provides effective protection only when the structure is located away from areas where channelized flow and high velocities occur.

Equations that predict flow conditions in streets on fans were developed and tested in the physical models. These equations are potentially useful in the design of street conveyance and local dikes. Sample equations for forces on structures and scour around elevated structures were developed based on physical model data.

Conclusions Regarding Hazard Delineation Methods

Delineation of flood hazards has two basic purposes: the identification of flood damage risk for insurance rate setting and the specification of hydraulic conditions for the design of flood protection measures. These purposes require different levels of accuracy and detail. Insurance rate mapping seeks to provide an equitable distribution of the future flood damages among those at risk and requires hydraulic information that is representative of the average risk in a given part of the floodplain. Specific data on depth, velocity, and scour/deposition potential are required to design mitigation measures to withstand those hazards.

In the case of riverine flooding, a delineation of flood hazards for insurance purposes will often adequately define the design conditions for mitigation measures. Inundation is the primary cause of damage and is also the most important design parameter. Since each event of a given magnitude will always damage the same properties, there is no uncertainty about properties at risk. On an alluvial fan, however, velocity and scour potential are also important factors in flood damage and mitigation design. These factors, as well as inundation depth, vary from one flood to the next, and are not distributed across a fan in a predictable way. Consequently, delineation of hazards for mitigation measure design requires more site-specific detail than that required for insurance rate maps.

It can be reasonably argued that the existing alluvial fan hazard delineation method provides an adequate basis for insurance rate setting because it provides a uniform, consistent mechanism for estimating risk and identifying general hazard levels. However, it is likely (even probable) that this method will underestimate the actual depths and velocities that will impact particular structures during a 100-year event, because it spreads the flood risk across the fan. What is needed, then, is a separate method that provides site-specific information about depths, velocities and scour or deposition potential during a 100-year event.

Development and application of such method should consider the following issues. (1) The appropriate level of protection can be defined at either the fan apex (similar to the riverine flooding method). These definitions produce radically different predictions of flooding conditions. (2) The nature of the flooding process is highly complex and unstable, and varies with location and each flood event. A simple method cannot adequately represent conditions that will affect a particular structure during a 100-year event. (3) Site-specific conditions such as local topography, sediment type, and slope may strongly influence the required design of flood protection measures. (4) Development on a fan has a much greater influence on flood hazards than it does under riverine conditions because upstream structures may divert, detain or concentrate flows. (5) The use of a separate method to define flood mitigation requirements could result in two sets of floodplain maps for fans. Alternatively, FEMA or local agencies could require that developers use the method to define hydraulic design conditions.

Recommendations

The following approach to flood mitigation on alluvial fans was recommended as part of the Anderson-Nichols study. (1) Field investigations should be performed to define watershed and fan characteristics and past flooding behavior. (2) Topographic mapping of the fan surface should be developed to identify past flow paths, incised channels, biases, and obstructions. (3) Apex hydrology should define the 100-year flood for the entire fan. (4) The resultant flow should be routed down the fan based on empirical equations and taking into account fan characteristics and development. (5) Hazard zones (related to channelized, braided and sheet flow conditions) can then be identified based on the routing and depths, velocities and scour potential defined within each zone. (6) Mitigation measures can then be selected and designed based on hazard zone, hydraulic conditions, and a management plan for the alluvial fan as a whole.

The following suggestions for further efforts were developed with alluvial fan flooding in mind, but are potentially applicable to other special hazards as well.

Science

- Field investigations and data compilation
- Selected, goal-oriented research and development regarding key flood-related processes
- Verification of empirical models using field data

Technology Transfer

- Usable methods based on available data
- Design standards for mitigation measures
- Sample specifications for floodplain management

Communication

- Mitigation guidance documents
- Hazard quantification guidance documents
- Community awareness meetings

Users/Uses

- User assistance programs
- Expertise available on call

Evaluation

- How well have/are methods working?
- Feedback to science

UNIQUE HAZARDS IN SOUTHERN CALIFORNIA

James E. Slosson
Chief Engineering Geologist
Slosson and Associates

Extent of "Unique" Hazard Problems

In southern California (Ventura County south through San Diego County) the mud flow, debris flow, and alluvial fan hazards exceed those caused by "clearwater" floods. The obvious reason is that this part of California has progressed in a responsible manner to protect the people and most properties from the conventional clearwater flood whereas little has been done to avoid mud flow and debris flow hazards.

The total dollar loss from clearwater flooding likely will continue to somewhat exceed mud flow and debris flow losses. However, the loss of life will probably continue to range from 5 to 1 to 10 to 1 greater from mud flows and debris flows.

Principal Advantages and/or Problems with Existing Approaches

For mud flow and debris flow loss (property and life), the problems are:

- Failure to recognize and delineate the areas prone to mud flows and debris flows.
- Failure to adopt regulations requiring recognition and mitigation. The City of Los Angeles seems to be the only enlightened local government to attempt to develop regulatory control (see attached).
- Reasonably administered and defined insurance coverage must be made available.

Recommendations

There are neither provisions nor guidelines for mapping and regulating hazards related to mud flow and debris flow. The insurance coverage currently may not cover all areas subject to these hazards. The insurance rates for mud flow and debris flow coverage do not reflect the degree of the hazard and do not encourage mitigation. As currently applied, it is unfair to those attempting to avoid or mitigate and very generous to the derelict.

It is also recommended that others follow the lead of the City of Los Angeles and require professional/technical reports that address both the problem and mitigation. Apply these regulations uniformly and effectively enforce them using qualified professionals on local government staff (or consultants by contract). Equate the insurance rate to the hazard and the mitigation. I expect very little increase in cost with this approach. Additionally, this approach will greatly reduce and/or eliminate the cost of litigating the losses.

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CITY OF LOS ANGELES

CALIFORNIA

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DEPARTMENT OF
BUILDING AND SAFETY
4TH FLOOR CITY HALL
LOS ANGELES, CA 90012

JACK M. FRATT
GENERAL MANAGER

TOM BRADLEY
MAYOR

August 31, 1982

Board File #82.311.3

NOTICE OF PUBLIC HEARING

PROPOSED RULE OF GENERAL APPLICATION -
SLOPE STABILITY EVALUATION AND ACCEPTANCE STANDARDS

On Tuesday, October 12, 1982, the Board of Building and Safety Commissioners will conduct a second public hearing on the Proposed Rule of General Application - Slope Stability Evaluation and Acceptance Standards.

The hearing will be conducted at 2:00 p.m., in Room 416 of the Los Angeles City Hall. Comments from interested persons can be presented at the hearing or made in writing prior to the date of the scheduled hearing, addressed to the Board of Building and Safety Commissioners, Room 416, Los Angeles City Hall, 200 North Spring Street, Los Angeles, California 90012.

COMMENTS: This Rule of General Application is intended to provide uniform requirements for the evaluation and acceptance of slope stability determinations made within the City of Los Angeles.

An earlier draft of this rule was the subject of a public hearing conducted by the Commission on September 9, 1980. As a result of the comments received and additional meetings between the Department and the American Society of Civil Engineers, Building and Safety Task Force Committee, the proposed rule has been revised; this revised draft, included herewith, incorporates most of the suggestions of all concerned.

S. S. NAIMARK, Secretary
BOARD OF BUILDING AND
SAFETY COMMISSIONERS

ww:ghw

485-5226

Attachment

CITY OF LOS ANGELES
CALIFORNIA

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DEPARTMENT OF
BUILDING AND SAFETY
402, CITY HALL
LOS ANGELES, CA 90012
JACK M. FRATT
GENERAL MANAGER

August 4, 1982

PROPOSED RULE OF GENERAL APPLICATION -
SLOPE STABILITY EVALUATION AND ACCEPTANCE STANDARDS

A. Purpose: This Rule of General Application is to provide uniform requirements for evaluation of and standards for acceptance of stability of slopes within the City of Los Angeles. These requirements include consideration of pertinent engineering geologic and soils engineering factors of the most critical field conditions that may reasonably be expected at the project location. These requirements include documentation and recommendations needed to determine if the site as proposed to be developed has an acceptable level of stability.

B. Application: A stability analysis will be required for cut, fill, and natural slopes whose gradient exceeds two horizontal to one vertical, and for all slopes that expose incompetent bedrock or unfavorable geologic structure such as unsupported bedding or that contain evidence of prior instability or landslide activity. Analysis is to include deep-seated and surficial stability evaluation under static load conditions.

C. Safety Factor Required: The Municipal Code specifies 1.5 as the minimum acceptable factor of safety for cut, fill and buttress fill slopes. This will also be interpreted to apply to natural slopes.

Safety factor is defined as the quotient of the sum of forces tending to resist failure divided by the sum of forces tending to cause failure.

New buildings shall not be constructed upon a site that is adjacent to cut, fill or natural slopes unless such slopes have a determined safety factor of at least 1.5 against deep seated and surficial failures.

EXCEPTION: Construction may be permitted on a site without a determination of surficial slope stability provided:

(a) Any potential surficial slope failure can be confined to remote or unused portions of the site located at least 15' from all structures, unless such portions are designed as permanent channels to prevent the accumulation of mudflow and debris and damage to the structures. Remote or unused portions shall not include accessory areas such as pools, driveways, parking or landscaped areas. NOTE: This provision shall not apply to any area within the boundary of a proposed subdivision or parcel map nor to any site where the potential debris will flow onto an adjoining property whether improved or not.

(b) An estimate of the magnitude and location of displaced material and debris that may occur in the event of slope failure is made by a soils engineer or engineering geologist.

(c) The design and contruction details of any permanent devices used to protect structures or prevent reflection of such debris onto adjacent sites are approved by the Department. These permanent devices may utilize design concepts of isolation, containment, deflection or channelization.

(d) Provision is made for equipment access to all areas which may need future maintenance.

(e) A copy of a sworn affidavit which has been recorded by the County Recorder stating that specified areas of the site may be subject to surficial failure is received by the Department. The affidavit shall notify future owners of their responsibility to provide maintanence of any protective devices.

Minor additions or alterations may be made to existing improvements where acceptable devices are provided to mitigate potential damage from failure of adjacent slopes and where the potential hazard to life or property is not increased.

D. Type of Analyses:

1. Deep-Seated Stability: Evaluation of slopes for safety factor against deep-seated failure shall be in general conformance with the following:

   a. The potential failure surface used in the analysis shall be composed of arcs, planes or other shapes considered to yield the lowest factor of safety and to be most appropriate to the soil and geologic site conditions. For reasonable homogeneous soils, an arcuate failure surface is considered adequate. In cohesive soils, a vertical tension crack may be used to aid in defining the potential failure surface. The potential failure surface having the lowest safety factor shall be used in the analysis.

   b. Loadings to be considered are gravity loads of potential failure mass, seepage forces and external loads. The potential for hydraulic head is to be evaluated and its effects included when appropriate. Saturated soil weight shall be used in computations for all soils above piezometric surface.

   c. The evaluation of competent massive bedrock which does not exhibit unfavorable jointing or bedding need not include calculations.

2. Surficial Stability: Evaluation of the slope surface for safety factor against surficial failure shall be based either on an analysis procedures for an infinite slope with seepage parallel to the slope surface or on other methods approved by the Department. For the infinite slope analysis, the minimum assumed depth of soil saturation is the lesser of three (3) feet or depth to firm bedrock. Soil strength characteristics used in analysis are to be obtained from representative samples of surficial soils that are tested under conditions approximating saturation.

E. Material Properties: The soil engineer is expected to use judgment in the selection of appropriate samples and in the determination of shear strength characteristics befitting the present and anticipated future slope conditions. To best accomplish this phase of the analysis, the project engineering geologist should advise the soil engineer on pertinent geologic conditions and materials observed during the site investigation. The following guidelines are provided for evaluating soil properties.

1. Soil properties, including unit weight and shear strength parameters (cohesion and friction angle), may be based on conventional field and laboratory tests. Tests shall be made on an appropriate number of samples removed from test pits that represent the material in a particular slope. At least one test shall be made on the weakest plane or material in the area under test and shall be made in the direction of anticipated slippage. Except for very limited slopes areas normally more than one test pit will be required.

2. Testing of earth materials shall be performed by an approved soil testing laboratory in accordance with Section 98.0503 of the Code.

3. Shear strength parameters used in stability evaluations may be based upon peak test values where appropriate. Residual test values shall be used for previous landslides, along shale bedding planes, highly distorted bedrock, over consolidated fissured clays and for organic topsoil zone under fill.

4. Prior to shear tests, samples are to be soaked to approximate a saturated moisture condition.

5. An arbitrary residual angle of shearing resistance of 6 degrees and cohesion of 75 pounds per square foot may be used to represent the strength on shale bedding and in landslide debris in lieu of parameters determined by laboratory testing.

6. Analysis of failures of existing slopes that are similar to the slope under consideration in terms of location, configuration, height, geology, and materials, may be used to establish shear strength parameters.

7. Soil strength characteristics of offsite slope materials may be based upon tests of similar materials or nearby properties when the qualified persons making the report state that in their opinion the offsite material possess strength characteristics equivalent to the material tested.

F. <u>Contents-of-Reports</u>: A report shall be submitted to the Department which includes the following items:

1. Recommendations for site development that will provide at least the level of stability specified in Section C of this rule.

2. An assessment of potential geotechnical hazards affecting the site.

3. A statement regarding location of potential ground water that may develop within the slope during and/or after major storm seasons and measures needed for ongoing stability.

4. Description of exploration performed as required by Rule of General Application 5-67 titled, "Rules and Regulations for Hillside Exploratory work."

5. Plot plan or topo plan showing locations of test pits and the areas they are assumed to represent.

6. Complete description of shear test procedures and test specimens.

7. Shear strength plots that include identification of sample tested, whether values reflect peak or residual strengths, and moisture condition at time of testing.

8. Comment on sample selection and confirmation that the samples tested represent the soil-bedrock profile along the potential failure path.

9. Calculations and failure surface cross sections used in stability evaluations.

10. General comments as to the stability of slopes from the effects of earthquakes concerning ground rupture, landslides, and differential movement.

11. Description of earth materials observed in test hole borings and test trenches to include characteristics such as bedding attitudes, joint spacing, fault zones, location of bentonite beds, etc.

12. Recommended drainage devices including subdrain systems below fills and behind stabilization structures.

MUD FLOOD, MUDSLIDE AND ALLUVIAL FAN HAZARDS

David R. Dawdy
Consulting Hydrologist
Dames and Moore

Mud flood and mudslide hazard areas are more limited in extent than alluvial fan flood hazard areas. This is because all mountain fronts debouching upon a plain have a potential for the creation of an alluvial fan. In the arid West, the debris delivered to the apex of the fan is greater than the amount that can be carried across the plain by the limited amount of stream flow. In areas of greater rainfall and runoff, alluvial fans form more slowly, or not at all. The result is that alluvial fans form over much of the western United States, and development on the fans is subject to flood hazard.

Mud floods and mudslides are more restricted in extent because they require steeper slopes and particular geologies in order to occur. Mud flood and mudslide flood hazard areas occur only in particular areas within states at places where the slopes and soils are conducive to mass land movement, and even in those areas their real extent is less than that for alluvial fans. A wall of mud is more spectacular, however, and makes larger headlines, so that those areas receive a disproportionate amount of publicity in relation to the true extent of the hazard.

Major Problems

Mapping of mud flood and mudslide flood hazard areas is at a primitive stage. The Los Angeles County Flood Control District (LACFCD) has an excellent data base and a good understanding of the problem, but has not been able to develop a reproducible and defensible method for mapping Los Angeles County. Because of this, their methods cannot be codified for use elsewhere. Both the U.S. Geological Survey and the Hydrologic Engineering Center are involved in or contemplating the development of a method, but nothing is known as yet of the direction of their work. Perhaps what is needed is for FEMA to take a limited area outside Los Angeles County—say in the San Gabriels in San Bernardino County where mud floods have occurred—and use that area as a test to develop a method that would apply to Los Angeles County as well as the rest of Southern California. That method could then be tested in Utah on some of the areas just north of Salt Lake City with similar problems. The point is to find an area that is not politically sensitive and sole source to a consultant who has a proven track record on producing innovative solutions to complex hydrologic engineering problems.

Mapping of alluvial fan flood hazard zones is much better established than is mapping of mud floods and mudslide floods. The problems with the method are ones of obtaining more accurate solutions. Thus, the effects of infiltration on the fan, of rainfall on the fan, of the assumptions of distribution of flow channels across the fan, and of avulsions on flood hazards are areas to be improved. Some of these are to be investigated soon. There should be a program for the identification of problems such as these, a means for the setting of priorities for their solution, and a procedure within FEMA to obtain those solutions.

Ten to 20% of flood-affected areas in the western states consist of areas on alluvial fans. Many cities in the West are built primarily on alluvial fans—Wenatchee, Washington; Las Vegas, Nevada; Palm Springs, Palm Desert and Rancho Mirage, California. Alluvial fans are seen as ideal potential development sites, because of the excellent views they provide. Percentage of total losses is high and going higher if there are no controls on alluvial fan development.

The rate structure for flood insurance on alluvial fans should be studied so that "actuarial" rates are actually actuarial. Flood frequency studies in arid zones are less accurate than in other areas because of the problems with desert hydrology. Log Pearson III analysis probably biases the estimate of extreme events, such as the 100-year flood, downward. My cursory study of the estimates for the 100-year floods for Wenatchee found that they were probably low, although the appeal stated that they were too high. Basing desert hydrology solely on gaged sites is not the most efficient means to estimate extreme events. Spatial correlation is small for summer thunderstorms, so that events are more important than are continuous records, and, thus, a station year approach may be more appropriate for statistical analysis in arid regions. Some serious thinking about how to set actuarial rates in arid regions is in order. That is where the people are moving, and that is where the development is taking place most rapidly.

Sugar dikes of local materials should be discouraged as a flood amelioration measure. Flash floods do not like to turn corners. Any attempt to direct flows must provide for excessive (by standard engineering approaches) super elevation, and all bends must be reinforced and protected so that they will not fail through erosion and overtopping. Development measures should expect erosion to occur wherever mud and water are forced to change their angle of flow. Erosion around pilings should be expected, and depth of burial should be based on some calculation concerning potential erosion.

Improvement of Approaches

FEMA should have an in-house advisory group or a panel of outsiders to brainstorm on data needs and research and development needs to further the National Flood Insurance Program—both in terms of insurance and floodplain management. That group should set forth the needs, with priorities and estimates of funding. These needs should be specific, and the problems they are to solve for FEMA should be detailed.

FEMA should use its historic cooperation with the other federal agencies to achieve some of the needs so identified. For example, if a particular type of data collection is deemed necessary for a particular type of flood hazard—alluvial fans, for example—then FEMA should enter into discussions with the USGS, and support their possible ultimate request for funds to implement a general data program of particular interest to FEMA.

Similarly, the Corps' experience in damage assessment should be utilized in the assessment of damage potential for the unique hazard zones as well as for the more normal riverine case with which they are more familiar, and in which they are the accepted experts. When time is of the essence, private consultants should be used.

If FEMA expresses its needs in interagency committees and if the other agencies see that those needs can be used to sell a program for themselves, a good deal of productive cooperation can result.

MANAGEMENT OF HIGH RISK FLOOD HAZARD AREAS

John M. Tettemer
John M. Tettemer and Associates
Los Angeles, California

Pilot Mapping and Modeling

Alluvial cones, mudflows, and sediment laden streams need to be mapped as Special Flood Hazard Areas requiring special management. Management considerations include radial flow, sensitivity to diversion and collection, erosion, and sedimentation. The entire cone or floodplain should be identified for management, based on topographic and geologic evidence of previous flows, not just a limited area based on clear water hydraulics.

Areas in need of such mapping include portions of Los Angeles, San Bernardino, Orange, Riverside, Ventura, Santa Barbara, and Imperial Counties in California; Clark County in Nevada; Davis, Salt Lake, and Utah Counties in Utah; Pima, and Maricopa Counties in Arizona; and Bernalillo County in New Mexico.

One of the most serious policy issues affecting the mapping of these areas is concern about accuracy and precision. Mudflows and alluvial cone mapping procedures are not yet advanced to the same level of "accuracy" as those of clear water hydraulics. Program administrators have been reluctant to proceed with mapping such areas because of concern about accuracy and defensibility of the maps. This caution may have had its origin in the early days of the NFIP when the "approximate" Flood Hazard Boundary Maps were found to contain many errors.

The result is that after 11 years into the program there are still many areas that need to be managed but which are unmappable under the clear water criteria. These are the areas subject to development. Local officials responsible for regulation of development consider these areas to be free of problems and routinely approve roads, grading, walls, and other improvements that may be subject to hazard or may increase the hazard to other developments.

We cannot afford to wait for refined procedures. We should get these areas identified, even approximately, and give floodplain managers, local politicians, and developers improved visibility over potentially hazardous areas. We recommend adoption of a pilot program as described in the section below entitled, "Recommended Changes in the Flood Insurance Program for Alluvial Cones."

Model Regulatory Approaches

The City of Las Vegas ordinance is one that brings to bear a broad cross-section of city functions on flood hazard reduction. Existing programs do not require any recognition of the hazards. The Los Angeles County Flood Control District floodway mapping and community information program, the Las Vegas alluvial cone master planning model, and the Las Vegas development permit review procedure are all innovative approaches that can be used as models by other local entities.

Several specific research tasks should be undertaken. In priority order to set required standards immediately, they are:

- Development of improved engineering design for stabilizers, toe protection, drop structure, and cutoffs;
- Development of engineering procedures for predicting erosion and mudflow; and
- Development of standards relations governing mudflow behavior.

A long-range objective would be the scientific verification of the standards, based on continuing research.

Recommended Changes in the Flood Insurance Program for Alluvial Cones

1) Identify alluvial cones on the flood insurance map as Special Flood Hazard Areas requiring special consideration of radial flow, sensitivity to diversion and collection, erosion, and sedimentation. This identification should be based on the topographic and geologic extent of the cone, rather than on hydraulic flow computations.

2) Require local government to develop and adopt a master plan for each alluvial cone, showing the relationship between development and flood flows. The master plan should address development assumptions, erosion and sedimentation, and how the transition from existing conditions to the master plan configuration will be managed.

   If flood and sediment control facilities are part of the master plan, the areas in which development is conditional on the availability of the master plan facilities should be identified.

3) Provide for removal of the Special Flood Hazard Area designation upon demonstration by local government that the hazard has been mitigated by the installation of elements of the master plan.

4) Benefits of NFIP (availability of flood insurance and grants-in-aid within the SFHA) are dependent on adoption of the master plan and management plan. The master plan describes the ultimate development configuration safe for 100-year flood. The management plan describes how the transition from existing conditions to the master plan will be

managed. Implementation of the master plan element is the only basis for appeal.

5) Apply the A Zone insurance rate over the entire cone.

LESSONS LEARNED FROM ALLUVIAL FAN FLOODING

Tim Yeh
U.S. Army Corps of Engineers
Los Angeles District

The Corps had encountered problems both on flood hazard identification and mitigation measures for potential development sites located on alluvial fans in the early 1970s. Those tasks are part of our technical assistance program, which we provide to agencies on request. However, our method of hazard identification, evaluation, and mitigation recommendation were mostly based on engineering judgment; and our recommendations for structural flood protective works were merely elements that were desirable but did not have criteria guidance.

Lessons learned on alluvial fans in recent years have helped us to conclude that flooding could occur at any place on the alluvial fan. The fan is the area immediately adjacent to the mouth of the canyon where the gradient is steep and flow velocity high. The most dependable hazard mitigation measure is the construction of a combination of debris basins and concrete channels to protect lives and reduce property damages. Our flood lessons have been gleaned from two fans: Santa Paula and Cucamonga. Communities have developed on these fans, and both are within 50 miles of Los Angeles.

Our flood hazard identification experience was gained from the community of Santa Paula, located on the fan created by Santa Paula Creek. The creek has a drainage area of 45 square miles. Because the community is immediately below the mouth of the canyon, the creek has been trained to drain from the side of it in a course that curves away from the city. The Corps completed a flood insurance study for the community in 1978. The overflow map delineation was based on the assumption that heavy debris would deposit at the curve and choke up the creekbed so that the floodwater would change course on the alluvium and inundate the community on the entire fan. The creekbed was about 150 to 200 feet wide with bank heights ranging from 14 to 21 feet. Our mapping could have been controversial if it had not been verified by a major flood two weeks before we made our presentation to the public. An eyewitness, who resided at the location were we had made our debris blockage assumption, described to us how he had lost 40 feet of his backyard by watching the toe cutting and top sloughing of the creek bank during the low flow stage. Subsequently, heavy boulders had rolled into the floodwaters and created deafening noises, drowning out the thunder normally associated with the lightening that he saw. His description convinced us that if a 100-year flood should occur, the flood path would have followed the path we depicted.

Another major flood in San Bernardino County in 1983 convinced us that the Corps' recently completed Cucamonga Creek Project did, in fact, prevent major flood damages for the population in Cucamonga. The Corps' project consists of a series of debris basins and concrete channels, which protect an area approximately six by six miles immediately next to the foothills. The entire fan is now flood-free from the canyon creeks, and the Corps no longer has to make conservative flood hazard evaluations for sites about which we have doubts; neither do we have to furnish mitigation recommendations for which we do not have design criteria.

Suggestions for future hazard identification and management on alluvial fans, based on lessons learned, are:

- Simply restore the delineation method for the entire fan as an AF Zone with a two-foot average flood depth for purposes of FEMA mapping.

- Set up a special tax assessment district to provide future comprehensive flood control protection on alluvial fans. This measure may encourage relocation of existing occupants and/or discourage proposed developments.

- The only further study needed for the assessment of "unique hazard" is in the development of a set of design criteria for floodproofing structures that could resist high velocity flow with movable debris loads on alluvium.

- Data collection for alluvial fan flooding should be limited to aerial surveys only after each major flooding event. It would be similar to the mapping done by the USGS for before-and-after comparisons.

SUMMARY REMARKS

Robert C. MacArther
Research Hydraulic Engineer
U.S. Army Corps of Engineers

The Need for Education, Training and Technology Transfer

Although regulations encourage local communities to actively participate in the work for the flood insurance program, no efficient methods exist to provide consistent and accurate technical guidance or data to local officials. Guidelines are often vague, leaving locals with a dilemma about how to proceed, what to assume or what is required. A well-organized education and technology-transfer program is greatly needed to alleviate these kinds of problems. The U.S. Geological Survey addressed some of the goals and needs for technology transfer in their 1982 Circular 880.

A Proposed Program

A FEMA-sponsored education and training program should consist of the following elements.

- Distribution of an educational program composed of a library of video tapes with support documents and workbooks. Tapes and support material would be loaned to cities and would target local city planners, managers and engineers. These materials would explain in easy-to-understand language a variety of important topics and issues, including technical, institutional and regulatory matters.

- Conduct follow-up regional workshops to answer questions raised by the tapes and workbooks. Invite city officials to attend nearby regional workshops to discuss materials presented in the tapes.

- Conduct additional specialized workshops at a later date, depending on the specific needs of the local communities. This would provide a good feedback mechanism for the training program and give local users more specialized training and assistance with their problems.

- Establish a toll-free FEMA telephone number that locals can call to get answers to technical, institutional or regulatory questions.

Video tape and workbook packages could cover a variety of specific topics dealing with various aspects of debris flow and debris flooding problems as well as the NFIP. The follow-up regional workshops would be more generalized than the specialized workshops and would deal with regional problems. Additional specialized workshops would focus on very specific local problems on a special request basis. Economic incentives could be used to attract participants.

COMMENTS AND SUMMARY WESTERN UNIQUE HAZARDS WORKSHOP

William J. Donovan
Office of Chief of Engineers
Department of the Army
Washington, D.C.

Technical Problems with an FIS on Alluvial Fans

One of the major problems with existing approaches to alluvial fan flooding is that the statistical analysis that relates the probability of given discharges at the apex of the fan is largely based on subjective assumptions and observations made by the modeler. At the time of maximum flow during a major flood event on an active fan, flow does not spread evenly over the fan but is confined to only a portion of the fan surface that carries the stormwater from the apex to the toe of the fan.

Flood flows on alluvial fans are frequently at critical depth and critical velocity due to steep slopes, thus, the channel is formed by the flow itself through erosion of the loose material that makes up the fan. Below the apex of the fan, the channel will occur at random locations at any place on the fan surface; under natural conditions, it is no more likely to follow a pre-existing flood path than it is to follow a new flood path. The probability of a point being flooded in a given flood event decreases from the apex to the toe of a fan because the down slope widening of the fan surface provides a greater area over which a channel of a given width may occur.

During major floods on active alluvial fans, peak flows may abruptly abandon one channel that had been formed during the flood and form a new channel. This phenomenon can cause a significant increase in the probability of flooding at a given point on a fan because of the increased channel widths that may cross a given contour during a given flood event.

Another problem concerns the alluvial fan Flood Insurance Study. Because of the necessity for refined mapping (1 or 2 foot contours), delicate two-dimensional hydraulic modeling, experienced engineers, and the need to coordinate results with all levels of government, the alluvial fan study is expensive and time-consuming compared to riverine studies. Heavy development on alluvial fans continues to proliferate because in many regions, they remain the only developable areas. Little effort is made by the developer to regulate construction or warn the purchaser that dangerous and devastating flooding can occur.

Problems with Existing Approaches

1. There exists little agreement on what is the appropriate "level of protection."

2. It is difficult to forecast whether the flood will be clear water, mud or debris.

3. No scientific approach is currently available to model mud or debris flows.

4. Too many subjective, judgemental assumptions and observations are required for erodible alluvial bed modeling, placing extreme emphasis on experience and skill.

5. Modeling techniques for alluvial fans are usually two dimensional and costly.

6. Detailed mapping and updating existing maps is costly.

7. Flood flows are usually at critical depth and critical velocity due to steep slopes.

8. Forest fires upstream of alluvial fans are a harbinger of devastating mud flows during or after heavy rainfall.

9. It is difficult to keep after channels free of debris: often huge boulders are present.

10. Poor building sites outside of alluvial fans create pressure to build in fan area.

11. There is a lack of regulations or land use ordinances (or enforcement of existing laws) in developable fan areas.

12. Existing FEMA regulations for communities in the regular NFIP do not solve the problem of flooding on alluvial fans.

13. It is difficult to make zoning decisions due to randomness of flow.

14. It is difficult for FIA to assess and sell high flood insurance premiums.

15. Insurance premiums vary in the same neighborhood if there is a mix of old and new homes--especially if older homes are pre-NFIP.

16. Expensive structural methods to solve flood and debris problems on alluvial plains are rarely justifiable and are likely to encourage encroachment into flooded areas.

17. Public utilities often suffer damage as new channels are forged by flood flows.

18. Some alluvial fan residents are willing to accept the risk of flooding in exchange for aesthetic amenities, lower cost homes or personal reasons.

19. Certain structural solutions on alluvial fans exacerbate flooding problems down stream.

Options for Future Actions

1. Provide training and technology transfer to local, state, and federal engineers and technicians on existing methodology.

2. Devise new, innovative, improved techniques for hydraulic modeling by funding study groups that have expertise and interest in flood mitigation on alluvial fans.

3. Organize quick response teams to observe, measure, photograph and study flood flows on alluvial plains.

4. Use assertive management of existing zoning laws, land use ordinances and FIA regulations in identified flood hazard areas.

5. Update existing land use master development plans.

6. Pass laws that would require a developer to provide flood protection for new homes/businesses constructed on alluvial fans that have a history of flooding.

7. Identify active alluvial fan areas and inventory the best available maps.

8. Consider the use of alternative lower cost methods to develop mapping, such as the new laser beam technology and digitized, automated systems.

9. Consider nonstructural mitigation methods such as flood proofing, evacuation, relocation, flood warning systems and flood insurance.

10. Refine methods to identify and improve the portrayal of the hazard and risk of living on alluvial fans.

11. Provide technical assistance to and/or consult with local, state and federal agencies on possible structural solutions, their justification and innovative financing.

12. Consider the low cost solution of forming debris detention basins that would capture most of the mud and debris away from the community.

13. Consider elevating homes 2' to 3' on strong pilings so that sheet flow at critical velocity will do minimal damage.

14. Consider construction of concrete chute diversions around developed areas.

A LEGAL PERSPECTIVE ON UNIQUE HAZARDS

Michael F. Richman
Attorney at Law
Van Cott, Bagley, Cornwall & McCarthy

From my vantage point as an attorney, as opposed to a professional who makes land use decisions on a day-to-day basis, I am chagrined by the professionals' insistence on exactitude in mapping. For want of exact mapping criteria, projects are being permitted when common sense dictates limitations be imposed.

In my experience only a few governmental entities have the requisite geotechnical expertise to produce maps with sufficient specificity. For the above reasons I would suggest the following approach to land use decisions based upon mapping.

- Use the existing available maps, updated to incorporate new information as it is discovered.
- If a project is proposed within a suspected geologically sensitive area, require the developer, as a condition of approval, to provide geologic reports utilizing the Los Angeles County geologic reporting standards. The "burden of proof" should be upon the developer.
- If a proposed project falls within a known geologically hazardous area, whether mapped or not, governmental entities should be prepared to withhold approval if the hazard cannot be designed around utilizing conservative geotechnical approaches.

It is in the first two situations above that many of the failures and concomitant lawsuits seem to arise. Government, not having specific maps, is hesitant to preclude construction. This practice belies common sense and exposes government to lawsuits and significant potential liability. This potential liability can be minimized, even in the absence of mapping, if government simply says "no."

Assume a developer proposes a development upon an alluvial fan at the base of a mountain range. Whether mapped or not, there can be no question that the development is potentially hazardous. If the planning commission, based upon competent data, refuses to grant approval, the developer can go to court and seek a reversal of that decision. If he obtains a reversal, and the project subsequently has a failure, there should be no governmental liability because it was on record as having opposed construction.

If government, however, in the absence of specific mapping (although the condition is known or should have been known) feels constrained to grant approval, government is exposed to potential liability. Reliance on existing mapping known to be inadequate will be no defense when a geologically hazardous project subsequently fails. The purpose of planning commissions, building departments and the like, is to protect the public safety. This duty is not dependent upon the specificity of mapping. It is dependent upon facts that are known, or should have been known. It is therefore suggested that reliance upon mapping is misplaced. Mapping is not a substitute for judgment.

It should be remembered foremost that mapping is only a tool in land use decision making. It is not a panacea to be relied upon with impunity. On-and-off site geologic reports must be utilized if government is to intelligently perform its function of guarding public health and safety.

SUMMARY REMARKS

H. Joseph Flynn
Assistant General Counsel
Federal Emergency Management Agency

The most remarkable thing about FEMA's mud flow litigation is that there is not more of it. I have a couple of hypotheses about why this is so. I say "hypotheses" because they are virtually impossible to verify, given the limitations on the available information. My first supposition is that the population at risk is under-represented among flood insurance policy holders. The second is that a disproportionate number of mud flow claims have been paid.

In his presentation, John Gibson of FEMA stated that mud flow claims represent well under 1% of all flood insurance claims. This is surprisingly low. It seems to me that the explanation is that the people who would most benefit from mud flow coverage either do not realize that it is availale or do not realize that they need it. Both of these assumptions make sense in light of the fact that FEMA has not published any maps designating mud flow prone areas. In my opinion, this situation has the potential for a later problem of major proportions. There are some communities, such as in the San Francisco Bay area, which are becoming more sophisticated about the availability of mud flow coverage. They are beginning to appreciate that the coverage is essentially free. The premium rates changed reflect the risk of clearwater riverine flooding. There is no extra charge for the mud flow increment of the flood insurance coverage. Without published maps, there is neither a mandatory purchase requirement (to spread the risk) nor a mitigation requirement.

My second supposition was that a disproportionate number of mud flow claims have been paid without questioning their validity. I do not mean to imply any judgment by the use of the term, "disproportionate." I simply mean that the proportion of mud flow claims paid to those presented is higher than the proportion of total claims paid to total claims presented. In my judgment, this stems from the difficulty of distinguishing mud flows that are covered under the Standard Flood Insurance Policy from other landslides which are not. This issue has been addressed at length in the two reports prepared for FEMA by the National Research Council of the National Academy of Sciences.

In the fifteen years or so that the National Flood Insurance Program has been insuring against mud flows, no more than a dozen lawsuits have been brought on this issue. There is only one written court opinion, Beck v. Director, Federal Emergency Management Agency, 534 F.Supp. 516 (N.D. Ohio, 1982). The homeowners in that case lived on the side of a hill which sloped down to a small stream. The slope had been excavated for the construction of the house and fill was then placed over a layer of clay. Spring rains caused the stream to swell, loosening the toe of the slope. The rain also saturated the fill and lubricated the slip surface. The surface of the hill gradually slipped down and away from the house, weakening the support for the foundation. The court found that the house was not damaged by inundation by mud flow. The principal reason was that the mud did not inundate the house—it did not rise and spread over any part of the house. The secondary reason was that the flow was not liquid. The movement was not turbulent; there was no distribution of velocities.

In January 1984, I investigated a claim in the Santa Cruz Mountains just west of Los Gatos. My impression was that there was no evidence of mud flow. There were no scarps at the top of the slope, no incisions or scoured channels. The ground cover appeared mature and undisturbed. I concluded, as had our investigating engineer, that the foundation failure was caused by surficial erosion or slippage below the failed area. However, when I took the deposition of the homeowner, she told me the stream below the house swelled to many times its normal size, knocked out several retaining walls and deck supports and deposited several feet of mud around her automobile. I very quickly recognized the description of a mud flood and settled the case.

FEMA has two mud flow cases pending now. One is in Salinas, the other in Richmond. The patterns of earth movement are similar in both cases. There is gradual slippage of earth down and away from the houses. There are tension cracks on the slopes in the vicinity of the houses. I am confident that we will successfully defend these claims on the basis of the Beck decision.

The difficulty that I face consistently in defending these lawsuits is that the definition of mud flow used in the flood insurance policy and in the regulations was drafted without reference to a precise scientific classification system. The critical part of the definition currently in use is "akin to a river of liquid and flowing mud." My strategy has been to focus on the mechanics of movement in contested cases. The definitional tools I have to work with are not ideal, but they are good enough that I can do something with them.

SUMMARY OF RECOMMENDATIONS

Dale Peterson
Federal Emergency Management Agency
Region IX

Extent of "Unique" Hazard Problems

The greatest flood hazard in Region IX is not from clear water flooding, but rather shallow flooding one to four feet in depth accompanied by sediment and debris. Traditional riverine flooding accounts for less than 10% of this region's flood threat. The mud flow and mudslide hazards defined in NFIP regulations are located principally in Southern California where the fire-rain cycle is very pronounced. Unfortunately, those hazard areas remain within Zone C of the community's FIRMs—unmapped and unregulated. The people at risk in these areas number in the hundreds of thousands. Just as important are the hazard areas of northern California where incohesive soils, rather than fire and loss of brush cover, result in a mud flow threat. This special hazard area remains unmapped and unstudied, but just as much a risk to existing and future development. Region IX is therefore unable to estimate the percentage of its special hazard areas subject to a mud flow, mudslide or mud flood threat.

Five percent of the region is subject to coastal inundation. The percentage of total losses and future development is low compared to the region's other flood-prone areas. Movable stream beds meander within a floodplain. Erosion of river banks, accompanied by sedimentation, alters the floodplain delineation with each flood. Fifteen percent of the region's flood hazard areas are movable beds. The population at risk can change with the erosion of a single event. This phenomenon was recently documented in the October 1983 Arizona floods. As a result, many of Tucson, Arizona's Zone C areas now lie within the floodway of the city's major rivers.

The greatest percentage of total area affected and loss potential, is within the region's areas of shallow flooding. Seventy percent of the region's hazard areas are subject to flow depths of one to four feet. The most severe of these are those subject to alluvial fan flooding. Sediment and debris flowing at velocities often over five feet per second create a condition as yet not completely understood by FEMA. The prime developable land areas in Region IX are subject to alluvial fan flooding. These areas—Palm Desert and Coachella Valley, California; Clark County and Las Vegas, Nevada; Washoe County and Reno and Sparks, Nevada; Los Angeles County and the San Bernardino County Basin will accommodate millions of dollars in new development projects and industry. The percentage of total loss is incalculable. To date these hazard areas remain unmapped and unregulated by any realistic floodplain management measures. It is a more accurate statement to say that existing FEMA shallow flooding regulations aggravate flooding and subject greater areas to risk.

Principal Advantages and/or Problems with Existing Approaches

Advantages of workshops such as this are that specific issues and recommendations surface among the professionals closest to the problem. FEMA policy makers can then become aware of the need to redirect program emphasis to meet very specific needs. A main problem with existing approaches has been FEMA's reliance on traditional mapping and floodplain management methods to provide an accurate assessment of the region's true risk. Existing approaches by FEMA policy makers have resulted in a lack of program credibility within the region because we cannot adjust or tailor our program to meet the specific needs of a community. More importantly, however, is the inaccurate flood insurance policy count of developments subject to risk because of failure to delineate the areas of true risk.

Recommendations

- Initiate a program to identify areas subject to alluvial fan flooding. The region can target specific areas where mapping is needed immediately.
- Revise, not rewrite, current floodplain management regulations to incorporate specific standards that address depth, slope, velocity and sediment transport for areas subject to alluvial fan and sheet flow or shallow flooding.
- Develop insurance rates that reflect the true risk.
- Revise community compliance review efforts to provide quality technical assistance, instead of continuing to produce CAPE reports in quantity.

STATE PERSPECTIVES: SUMMARY REMARKS

Robert E. Hendrix
Chair
Association of State Floodplain Managers
and
State Coordinator, NFIP
Nebraska Natural Resources Commission

The Western Unique Hazards Workshop was an important event for those concerned about the quality and extent of hazard identification for regional flood conditions throughout the United States. A knowledgeable and dedicated group of individuals gathered to address the unique floods hazards common to the western part of the country, and reached a number of positive conclusions and recommendations.

One prominent conclusion of the workshop was that alluvial fan flooding and sediment transport problems are not "unique hazards" as such, but rather particular types of flooding that are common to every flood event in the west. At present, the identification and regulation of these regional hazards is somewhat overlooked because of their "uniqueness", or rather the fact that they do not relate to the standard national concept of flooding. This is a condition of great concern and one that merits immediate attention.

It was agreed that before any effective mitigation measures can be taken, the hazard must be properly identified. To map and label an alluvial fan as an area with little chance of flooding reflects a perception of the problem that is simply inaccurate. It is regionally known that extensive property damage from flooding will occur, due to recent development trends in the west. Therefore, the area should be mapped accordingly. This is important not only for map credibility and hazard awareness but also from the perspective of proper insurance rating and the goal of actuarial soundness in the insurance program.

At present, when determining priority areas for a detailed flood study, two of the overriding factors are the number of flood insurance policies sold in the area and the number of claims submitted for flood damage. Without these supporting data, a detailed flood study has not been justified. It is clear, however, that without the proper identification of the area in relation to its respective hazard, neither property owners nor lenders will realize the need for flood insurance and, as a result, there will be no policies in force and no claims to submit. While this policy saves federal mapping costs, it does nothing for the property owners who are unprepared for a flood and the disaster assistance burden on the country. The number of claims and policies in force should not be the major factors in determining the need for detailed studies of non-standard riverine and coastal flooding conditions. In those situations greater emphasis needs to be placed on the potential for loss and the need to prevent future development.

There is a very real need for immediate mapping of the hazard areas—even by approximate methods. Conditions are ideal in a great many western communities to prevent unwise development: high hazard areas there are still uninhabited, but neither are they identified as being flood-prone. This opportunity to implement predevelopment and predisaster mitigation measures should not be lost.

Finally, by the end of the workshop it had become obvious that the only way these regional problems would improve would be for FEMA/FIA to take the lead. As the sole agency capable of changing the way these hazards have been treated, FEMA has the responsibility to listen to the technical experts and to adjust its thinking and programs accordingly. New programs and techniques are needed that emphasize identification and rating of hazards as they actually exist throughout the country rather than overlooking those that do not fit the standard flood mold.

WORKSHOP DISCUSSION

Given the diverse backgrounds of the workshop participants and the number of states and local governments represented, there was a surprising degree of agreement concerning the principal questions posed to participants.

Question 1:

How serious are alluvial fan, mud flood and mudflow problems in the West and Southwest, existing development, and growth potential?

Answer:

Workshop participants agreed that alluvial fan flooding, mudfloods and mudflows are major flooding problems in much of the arid and mountainous areas of Southern California, Utah, Nevada, New Mexico, Arizona, parts of Colorado, parts of Idaho and some areas in Washington State, Wyoming, and Montana. Clear water flooding where depth of inundation was the sole or principal damage factor may be a "unique"hazard in much of this area.

Ben Roberts, Consultant

"A study by the U.S. Army Corps of Engineers Natich Lab identified over 3,800 alluvial fans within a 19,500 square mile area of the Southwestern United States and estimated that over 30% of American Southwest deserts are occupied by alluvial fans."

Jim Slosson, Consultant, Southern California

"The total dollar loss from clear water flooding likely will continue to somewhat exceed mudflow and debris flow losses. However, the loss of life will probably continue to range from 5 to 1 to 10 to 1 greater from mudflows and debris flows."

Estimates of the magnitude of the problems provided by speakers or participants in their presentations and papers include (note this is not an exhaustive list)

Susan Santarcangelo, Flood Insurance Coordinator, Nevada:
"About 75-90% of the developable land in the state is susceptible to alluvial fan flooding of varying severities, depending on the size of the watershed and length of the fan."

Viki Thompson, FEMA Region 9. "Nine out of 10 disaster declarations with which I have worked since 1979 have had alluvial fan or mudflow components".

Dale Peterson, FEMA Region 9. "Traditional (clear water) flooding accounts for less than 10% of this region's flood threat."

Carl Blum, Los Angeles County Flood Control District. "2.6 million individuals live in areas potentially affected by mud hazards in Los Angeles County. In 1978 and 1980 flood disaster damage from mud exceeded $100 million".

Joseph Flynn, FEMA's General Counsel Office. Development in mud flood areas will create "a later problem of major proportion. There are some communities, such as in the San Francisco Bay area, which are becoming more sophisticated about the availability of mudflow coverage. They are beginning to appreciate that coverage is essentially free."

Les Bond, Flood Insurance Coordinator, Arizona. "Unique flood hazards (not confined to alluvial fan flooding or mud floods) predominate in 13 out of 15 of Arizona's counties.

A number of speakers (e.g., John Tettemer, Dennis Bechtel, Susan Santarcangelo, Dave Dawdy, Dale Peterson, Jean Brown, and others) emphasized that alluvial fan and mud flood areas were under rapid development in many high-growth areas like Clark County, Nevada; Salt Lake City, Utah; (and other communities along the Wasatch front); Los Angeles County, Marin County, Contra Costa County, San Diego County, Riverside County, San Bernardino County, Santa Barbara County, Monterey and Santa Cruz County and other counties in California, and many counties in Colorado (e.g., Telluride). Les Bond from Arizona suggested that these and other "unique flood hazards" predominated in 13 out of 15 of Arizona's counties. It was suggested that it would only be a matter of time before massive flood insurance claims would be forthcoming as landowners become aware that extremely low cost insurance was available for such areas.

Several speakers (Jim Slosson, Mike Richman) indicated a concern with the legal implications of permitting development in alluvial fan and mudflow areas in light of the inadequate mapping and regulatory standards for such areas and noted that many communities in California were now being sued as a result of flooding in 1978, 1980, 1982 and 1983.

Mike Richman (attorney, Salt Lake) described a recent California Supreme Court decision, Sprecher v Adamson, which opened the door for potential private landowner and local government liability due to natural flooding or mud flood/mudslide conditions on landowners' land which damages other lands.

Only Carl Cook (Oregon) indicated that alluvial fan or mud flood problems were not a serious problem in his state. He noted that fans occurred in Oregon but little development was occurring on them.

Howard Leiken (FEMA central office) stated that flood insurance dam data did not indicate severe alluvial fan or mud flood losses. John Gibson (FEMA's mapping program) indicated that both alluvial fan flooding and mudflows and mud floods were a concern but the number of flood insurance losses for such areas was small; that there were continued problems in achieving acceptable mapping criteria and that FIA was faced with other competing needs. However, several participants questioned the low FIA figures on alluvial fan and mudflow/mud flood problems and suggested that alluvial fan and mudflow and mud flood insurance losses were likely much greater than FIA central office believed due to lack of sufficiently specific claims information, that many losses were in fact disaster assistance rather than flood insurance loss and that the real issue was potential future losses due to the high growth in these areas and existing claims.

Several participants suggested that, given the widespread seriousness of alluvial fan and mud flood problems and the high growth potential for these areas, FEMA or other agencies should look carefully at disaster assistance and insurance claim data to determine the magnitude of the problems and should begin gathering such loss data more specifically.

<u>Question 2: How adequate are existing mapping, regulation, insurance and other approaches for managing and reducing losses in such areas?</u>

<u>Answer</u>: There was virtual consensus by speakers and panelists and in the discussion that followed that existing federal mapping, regulatory standard-setting, and insurance rating approaches for such areas were inadequate and, in some instances, misleading, (depending on the circumstances) because the approaches failed to consider:

- velocity of the water,
- debris, and
- erosion and deposition during a flood.

It was noted that, in general, many alluvial fans have been designated "shallow flooding" areas in FEMA mapping (Dave Dawdy, Dale Peterson) and that such designation does not reflect the severe hazards posed by high velocity and debris laden flows on the fan or sudden changes in channels.

Les Bond, Flood Insurance Coordinator, Arizona. "Most of the problems we have with floodplain mapping and management are related to the movement of solid materials during a flood; aggradation, degradation, braided channels, and channel migration.

In Mojave County, FEMA, over the objections of the state and the county, mapped alluvial channels as AO Zones with depths up to five feet and velocities of 11 feet per second. AO Zones, according to FEMA definition, have depths of only one to three feet. Mojave County asked that the entire width of the channels be designated as "floodway," which a community can do in a riverine situation. However, since FEMA had already designated them as AO Zones they would not map a floodway."

Dale Peterson, FEMA Region 9. "Seventy percent of the region's hazard areas are subject to flow depths of one to four feet...Existing FEMA shallow flooding regulations aggravate flooding and subject greater areas to risk. Existing approaches by FEMA policy makers have resulted in a lack of program credibility within the region because we cannot adjust or tailor our program to meet the specific needs of a community."

Les Bond, Flood Insurance Coordinator, Arizona. "The existing studies and maps do not accurately forecast the extent or depth of flooding and flood-related problems, either for present conditions or for the future."

Carl Blum, Los Angeles County Flood Control District. FEMA mapping does not consider debris or future development "because these two factors are not considered in the standard clear water method, the maps have a somewhat misleading effect on planners and publications in the area. There has been a push to use the federal mapping standards rather than local standards, which take into account future development and debris. This has resulted in nationwide criteria being used as evidence against local standards rather than as support to help communities identify their real hazards.

Mike Richman, Attorney, Salt Lake City. "From my vantage point as an attorney,...I am chagrined by the professional's insistence on exactitude in mapping. For want of exact mapping criteria, projects are being permitted when common sense dictates limitations be imposed...Reliance on existing mapping known to be inadequate will be no defense when a geologically hazardous project subsequently fails. The purpose of planning commissions, building departments and the like, is to protect the public safety. The duty is not dependent upon the specificity of mapping. It is dependent upon facts that are known, or should have been known. It is therefore suggested that reliance upon mapping is misplaced. Mapping is not a substitute for judgement".

Dennis Becktel, County Government, Clark County, Nevada. "The major problem faced by Clark County (Las Vegas metropolitan area) is the fact that alluvial fan flooding has not been adequately addressed in the National Flood Insurance Program.

"Another major weakness in the program is its failure to consider sediment as a component of the total discharge in evaluating the hydraulics of flooding.

"Other regional differences often are not taken into consideration in floodplain studies. One example is rainfall distribution."

Jerry Olson, FEMA Region 8, observed that a number of alluvial fan areas in Colorado were being restudied due to the inadequacy of the original methodologies.

Several speakers (John Tettemer, Jerry Olson) suggested that part of the problem was that FEMA mapping, regulatory standards, and insurance rating criteria had been prepared with Eastern and Midwestern problems in mind and that the hydrologic and geologic problems of the arid west were quite different. Some frustration was also expressed that little progress had been made in modifying such criteria to reflect regional needs despite directives from Congress as early as 1969 that mudslide areas be mapped and insured.

A number of speakers raised questions concerning the present flood insurance rating as unrealistically low for alluvial fan and mud flow/mudslide areas:

Jim Slosson, Consultant. "The insurance rates for mudflow and debris flow coverage do not reflect the degree of the hazard and do not encourage mitigation. As currently applied, it is unfair to those attempting to avoid or mitigate and very generous to the derelict."

Les Bond, Flood Insurance Coordinator, Arizona. "The insurance zone rates [in Arizona] where the highest actuarial losses have been experienced are: outnumbered A Zones, where detailed studies were not done; B Zones, where flooding should be shallow and infrequent; C Zones, which are supposed to be free of flooding; D-Zones which have not been studied; and A99 Zones where structural measures were supposed to provide protection. All of these have a higher loss ratio than numbered A Zones and numbered V Zones."

The reasons for lack of progress suggested by workshop participants included: continued problems with mapping methodologies; failure to develop land management standards, limited budgets; lack of coordination in insurance, land management guidelines and mapping; and a perception that alluvial fans and mudfloods were a low priority problem.

There was also considerable discussion during the workshop of efforts to develop mapping and analytical methods and land use standards exceeding those of FEMA. Some of the innovative efforts and new studies described included:

(1) FEMA's new alluvial fan mapping methodologies for study contractors.

(2) A study by Anderson, Nichols, Inc. under contract to FEMA to develop and test alluvial fan mapping methodologies and land management standards for fan areas.

(3) Studies by the USGS in San Francisco region and Utah to map mudflow, mudslide and other landslide areas and to develop and test mapping methodologies.

(4) Efforts of Los Angeles County to develop mapping methodology and regulatory standards for alluvial fan and mud flood areas.

(5) Efforts by Clark County, Nevada and other areas in Nevada to develop a management plan and regulations for alluvial fans.

(6) The efforts of Salt Lake City, the state of Utah and the USGS to map and develop management guidelines for debris floods, lake flooding, and other hazards along the Wasatch front.

(7) The efforts of Riverside County, Kern County, Santa Barbara County and San Bernardino County and the cities of Rancho Mirage and Palm Desert in California to map, regulate and otherwise manage alluvial fan and mud flood areas.

Question 3: Given limited budgets at all levels of government, how should states, FEMA or other federal agencies, and communities best improve the effectiveness of management for these areas?

Answer: Workshop participants agreed that the state of knowledge concerning mapping methodologies and regulatory standards for alluvial fan areas had progressed sufficiently to permit considerable improvement over existing approaches.

Suggestions for improving the effectiveness of management offered by speakers and participants included:

(1) Document successes. Several speakers suggested that success stories in implementing improved maps, regulations and other management approaches should be documented and emphasized.

John Tettemer, Consultant. "Let us accentuate successes rather than glamorize failures."

(2) Simultaneously address insurance, mapping and regulation. Flood insurance, mapping and regulatory standards should be simultaneously addressed (e.g., Frank Thomas, Bob Hendrix).

(3) Prepare development standards and guidelines. Improved development standards should be developed and applied by FEMA, states and localities for alluvial fan and mudflood areas.

Jim Slosson, Consultant. "It is...recommended that others follow the lead of the City of Los Angeles and require professional technical reports that address both the problem and the mitigation."

Kenneth Edwards and David Sheldon, Riverside County Flood Control and Water Conservation District. "Establish appropriate building standards for AO (depth) (velocity) zones...Erosion should be recognized as a velocity-induced hazard to development...Velocity should be considered one parameter by which scour and hence scour protection requirements can be established...Guidelines should be developed to address the density of development in AO Zones."

Tim Yeh, U.S. Army Corps of Engineers. "(A) set of design criteria for floodproofing structures that would resist high velocity flow with movable debris loads on alluvium (is needed).

Dale Peterson, FEMA Region 9. "Revise, not rewrite, current floodplain management regulations to incorporate specific standards that address depth, slope, velocity and sediment transport for areas subject to alluvial fan and sheet flow or shallow flooding."

(4) Improve Post-Disaster Mitigation. Better post disaster and mitigation guidelines and technique are needed for high risk areas.

Viki Thompson, FEMA Region 9. Additional requisition of high risk areas with funds from FEMA's Section 1362 may be appropriate. States and local governments should better assess hazards and implement mitigation standards and carry out their 406 responsibilities.

(5) Strengthen mapping criteria. Mapping criteria should be strengthened and study contractors better trained in assessment of special hazards.

Les Bond, Flood Insurance Coordinator, Arizona. "Separate mapping is needed for insurance and mapping for management...Mapping should occur on a county-wide basis."

Tim Yeh, U.S. Army Corps of Engineers. "Reinstate the AF zone classification for the entire fan."

Dennis Bechtel, Clark County, Nevada. "The AF zone should be reinstated. The AF zone should include a floodway designator (in an area of active alluvial flooding) that could enable a community to preclude development from these potentially dangerous areas."

"Mapping should be on a hydrologic unit basis."

John Tettemer, Consultant. "Alluvial cones, mudflows and sediment-laden streams need to be mapped as Special Flood Hazard Areas requiring special management. Management considerations include radial flow, sensitivity to diversion and collection, erosion and sedimentation. The entire cone or floodplain should be identified for management, based on topographic and geologic evidence of previous flows, not just a limited area based on clear water hydraulics."

Dennis Bechtel, Clark County, Nevada. "Maps generated by hydrologic basis and not by political boundary will facilitate review and ensure that nothing important is missed."

Kenneth Edwards and David Sheldon. "Allow with local concurrence, floodplain mapping consultants to exceed federal mapping standards by using more advanced hydraulic analysis techniques such as moveable bed models that would predict otherwise undetectable stream breakouts and channel migration."

Bob Hendrix, Flood Insurance Coordinator, Nebraska. "The number of claims and policies in force should not be the major factors in determining the need for detailed studies of nonstandard riverine and coastal flooding conditions. In these situations, greater emphasis needs to be placed on the potential for loss and the need to prevent future development...there is a very real need for immediate mapping of the hazard areas--even by approximate methods."

(6) Undertake preliminary mapping. Preliminary mapping based upon historical or other data should be carried out for alluvial fans and mud flood areas.

Carl Blum, Los Angeles Flood Control District. "Let's start with what we have."

John Tettemer, Consultant. "We cannot wait for refined procedures. Let's get these areas identified, even approximately, and give floodplain managers, local politicians, and developers improved visibility over potentially hazardous areas. We recommend adoption of a pilot program..."

(7) Revise insurance rates. Flood insurance rates should be revised to more fully reflect risks and encourage sound floodplain management.

John Tettemer, Consultant. "Apply the A-Zone insurance rate over the entire [alluvial] cone."

Joseph Hill, San Diego County. "Provide incentives for good floodplain management by local government through reduced flood insurance rates and support for local floodplain programs."

James Slosson, Consultant. "Equate the insurance rate to the hazard and the mitigation."

Dave Dawdy, Consultant. "The rate structure for flood insurance on alluvial fans should be studied so that it is "actuarial...some serious thinking about how to set actuarial rates in any region is in order. That is where the people are moving, and that is where the development is taking place."

Dale Peterson, FEMA Region 9. "Develop insurance rates that reflect the true risk."

(8) Better dissiminate information. Additional technical assistance on a multiagency basis and dissemination of existing data and information on mapping and management approaches is needed.

Bob MacArther, U.S. Army Corps of Engineers. "A well-organized educational and technology transfer program is greatly needed...A FEMA-sponsored education and training program should consist of: distribution of...a library of video-tapes with support documents and workbooks...[and] follow-up regional workshops to answer questions raised by the tapes and workbooks."

Susan Santarcangelo, Flood Insurance Coordinator, Nevada. "FEMA should provide more technical assistance by sponsoring workshops or classes (taught by experts practicing in the fields) on the technical aspects of regional "unique hazards". This is the perfect opportunity for FEMA to encourage the participation of such other technically oriented agencies as USGS and the Corps of Engineers, as well as persons from the private sector."

(9) More regional discretion is needed in addressing hazards. FEMA regions should be allowed more discretion in identifying and addressing regional problems and needs.

Susan Santarcangelo, Flood Insurance Coordinator, Nevada. "FEMA should leave more power for dealing with regional problems in the regional office."

(10) Encourage master planning. FEMA, other agencies and the states should encourage local master planning of alluvial fan and mud flood areas.

Carl Blum, Los Angeles County Flood Control District. "Don't spend money except where a local master plan has been adopted."

John Tettemer, Consultant. "Require local government to develop a master plan for each alluvial cone, showing the relationship between development and flood flows. The master plan should address development assumptions, erosion and sedimentation, and how the transition from existing conditions to the master plan configuration will be managed...Provide for removal of the Special Flood Hazard designation upon demonstration by local governments that the hazard has been mitigated by the installation of elements of the master plan...Benefits of the NFIP should be dependent on adoption of Master Plan and its management."

(11) Improve level of expertise. Problems with lack of local expertise could be dealt with better through certification of engineers and geologists (suggested by Mike Richman), improved permit evaluations, use of technical appeals boards (suggested by Jim Slosson),

improved training and education (suggested by many), technical assistance from expert agencies.

Susan Santarcangelo, Flood Insurance Coordinator, Nevada. "FEMA should not try to be the sole technical advisor. It should identify basic problems it would like to see addressed, then assist communities to find other government agencies with technical capabilities to deal with the problems to allow them to seek outside technical assistance. FEMA should coordinate, not duplicate."

(12) Improved structural approaches are needed. Management approaches other than planning, regulation and insurance should be more fully investigated and utilized in particular circumstances.

Bill Donovan, U.S. Army Corps of Engineers. "Consider the low-cost solution of forming debris retention basins that would capture most of the mud and debris away from the community. Consider construction of concrete chute diversion around developed areas."

(13) Additional research and testing. Additional research and testing of approaches is needed including demonstration projects.

Dave Dawdy, Consultant (referring to mud floods). "Perhaps what is needed is for FEMA to take a limited area outside of Los Angeles County--say the San Gabriels in San Francisco County where mud floods have occurred--and use that area as a test to develop a method that would apply to Los Angeles County as well as the rest of Southern California. That method could then be tested in Utah in some areas just north of Salt Lake City with similar problems."

John Tettemer, Consultant. "Research priorities include:
a. Development of improved engineering design for stabilizers, toe protection, and drop structure;
b. Development of engineering procedures for predicting erosion and mudflow; and
c. Development of standards relating to mudflow behavior."

Les Bond, Flood Insurance Coordinator, Arizona. "(A)n all-out research program is needed to develop methods for forecasting sediment transport and its impacts on floodplain management: aggradation, degradation, channel migration and the behavior of alluvial fans and other distributary systems. The cost of these studies is dwarfed by the potential damage if they are not done."

<u>Carl Blum, Los Angeles County Flood Control District</u>. "A team of experts (FEMA, USGS, Corps of Engineers) needs to be assembled and armed with the best information to develop an acceptable (mud hazard) mapping method as soon as possible."

Although participants agreed on many points, there was disagreement concerning:

(1) The appropriate future roles for the states, federal government, and local government in improving the effectiveness of management of high risk. All participants agreed that the federal government should not encourage unsound development through unrealistic maps, inadequate regulatory standards or unrealistically low insurance rates. But participants disagreed as to the scope of the federal role. Some favored major new federal mapping and a regulatory standard-setting role. Others suggested that perhaps the federal government had "done all that could be expected of it" and that states and communities should play a larger future role in improving the effectiveness of management. There was agreement that if the federal government was to continue to map, establish regulatory guidelines, and insure such areas, it should do it realistically with appropriate methodologies.

(2) The adequacy of existing mapping and methodologies and regulatory standards for detailed regulation of such areas, particularly with regard to mudflow and mudflood areas. Continued definitional problems in distinguishing mud floods, mudflows and more traditional mudslides were noted.

(3) The usefulness of very precise maps identifying hazards on alluvial fans, since human activities affect the hazards greatly and conditions change quickly over time.

Prepared by Robert C. MacArther
The Hydrologic Engineering Center
U.S. Army Corps of Engineers
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MUDFLOWS/DEBRIS FLOWS
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ATTENDANCE LIST

WESTERN UNIQUE HAZARDS WORKSHOP
February 15-16, 1984

Byron Aldridge
U.S. Geological Survey
345 Middlefield Road, M.S. 466
Menlo Park, CA 94025
415 323-8111 ext. 2337
FTS 467-2337

Dennis Bechtel
Clark County Department of
Comprehensive Planning
225 Bridger Avenue, 7th floor
Las Begas, NV 89155
702 386-4181

Carl L. Blum
Los Angeles County Flood
Control District
2250 Alcazar Street
Los Angeles, CA 90033
213 226-4321

Leslie Bond
Arizona Division of Water Resources
99 E. Virginia Avenue
Phoenix, AZ 85004
602 255-1566

A. Jean Brown
State Department of Water Resources
P.O. Box 388
Sacramento, CA 95802
916 445-6249

William M. Brown, III
U.S. Geological Survey
345 Middlefield Road, M.S. 998
Menlo Park, CA 94025
415 856-7112

Patty Clendenning
Federal Emergency Management Agency
Region IX
The Presidio
San Francisco, CA 94129
415 556-9840

Carl L. Cook, Jr.
Oregon Dept. of Land Conservation and
Development
1175 Court Street, N.E.
Salem, OR 97310
503 378-4926

Tim D'Acci
Washington State Department of Ecology
Mail Stop PV-11
Olympia, WA 98504
206 459-6356

David R. Dawdy
Dames and Moore
3055 23rd Avenue
San Francisco, CA 94132
415 681-0957

William J. Donovan
U.S. Army Corps of Engineers
20 Massachusetts Avenue, N.W.
Washington, D.C. 20314
202 272-0169

Kenneth Edwards
Riverside County Flood Control District
P.O. Box 1033
Riverside, CA 95202-1033
714 787-2885

H. Joseph Flynn
FEMA Office of General Counsel
500 C Street, S.W.
Washington, D.C. 20472
202 287-0386

John Gibson
Federal Insurance Administration
Federal Emergency Management Agency
Washington, D.C. 20472
202 287-0750

Robert E. Hendrix
Nebraska Natural Resources Commission
P.O. Box 94876
Lincoln, NB 68509
402 471-2081

Joseph C. Hill
County of San Diego Public Works
Flood Control
5555 Overland Avenue
San Diego, CA 92123
619 565-5322

ATTENDANCE LIST

WESTERN UNIQUE HAZARDS WORKSHOP
February 15-16, 1984

Melinda Hulsey
Federal Insurance Administration
Federal Emergency Management Agency
Washington, D.C. 20472
202 287-0269

Bob Ingram
825 E. 3rd Street
San Bernardino, CA 92320
714 383-1718

John Kashuba
River County Flood Control District
Box 1033
Riverside, CA 95202-1033
714 787-2885

William Kockelman
U.S. Geological Survey
345 Middlefield Road, M.S..922
Menlo Park, CA 94025
415 323-8111 ext. 2312

Jon A. Kusler
J.A. Kusler Associates
P.O. Box 528
Chester, VT 05143

Lorin Larsen
Utah Emergency Management
1543 Sunnyside Avenue
Salt Lake City, UT 84103
801 533-5271

Howard Lieken
Federal Insurance Administration
Federal Emergency Management Agency
500 C Street, S.W.
Washington, D.C. 20472
202 287-0720

Charles R. Lewis
Dames and Moore
7101 Wisconsin Avenue
Suite 700
Bethesda, MD 20814
301 652-2215

William H. Longenecker, Jr.
Coachella Valley Water District
P.O. Box 1058
Coachella, CA 92236
619 398-2651

Robert C. MacArther
U.S. Army Corps of Engineers
Hydrologic Engineering Center
20 Massachusetts Avenue, N.W.
Washington, D.C. 20314
916 440-2015

Ross MacKay
Federal Insurance Administration
Federal Emergency Management Agency
Washington, D.C. 20472
202 287-0250

Jerry Olson
Federal Emergency Management Agency
Region VIII
Federal Center, Bldg 710
Lakewood, CO 80225
303 234-6582

H. James Owen
Flood Loss Reduction Associates
4145 Maybell Way
Palo Alto, CA 94303
415 493-7198

Terry L. Paxton
Kern County Public Works
2601 0 Street
Bakersfield, CA 93301
805 861-2481

Garvin J. Pederson
Los Angeles County Flood Control
2250 Alcazar Street
Los Angeles, CA 90033
213 226-4186

William J. Petak
Institute of Safety and Systems
Management
University of Southern California
Los Angeles, CA 90089-0021
213 743-5060

ATTENDANCE LIST

WESTERN UNIQUE HAZARDS WORKSHOP
February 15-16, 1984

Dale Peterson
Federal Emergency Management Agency
Region IX
The Presidio, Bldg 105
San Francisco, CA 94129
415 556-9840

Michael F. Richman
Attorney at Law
50 South Main Street
Suite 1600
Salt Lake City, UT 84144
801 532-3333

Benjamin Roberts
Anderson-Nichols & Co., Inc.
2666 E. Bayshore Road
Palo Alto, CA 94303
415 493-1864

Susan A. Santarcangelo
State of Nevada Division of
Emergency Management
2525 S. Carson Street
Carson City, NV 89710
702 885-4240

James Slosson
Slosson and Associates
14046 Oxnard Street
Van Nuys, CA 91401
818 785-0835

John Tettemer
1952 Fairburn Avenue
Los Angeles, CA 90025
213 474-8338

Jens Thielmann
PRC Engineering
3600 Lime Street
Riverside, CA 95202
714 684-8060

Frank Thomas
Office of Loss Reduction
Federal Insurance Administration
Federal Emergency Management Agency
Washington, D.C. 20472
202 287-0222

Viki Thompson
Federal Emergency Management Agency
Region IX
The Presidio, Bldg 105
San Francisco, CA 94129
415 556-9840

David J. Tong
California Department of Water Resources
P.O. Box 6598
Los Angeles, CA 90053
213 620-4935

Tim Yeh
U.S. Army Corps of Engineers
P.O. Box 2711
Los Angeles, CA 90053
213 688-5454

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