of 1972 probably saved many people who chose to camp for months in tents outside their homes (*12*). Similar tremors prior to the Guatemala earthquake of 1918 led rich families to build wooden shacks (*tembleros*) in their courtyards in which they would sleep and seek protection when the tremors increased (*13*). Such preliminary tremors provide great motivation to begin preventive relief work by reinforcing homes, removing high objects and heavy overhangs, or moving to more aseismic alternate shelters. Neither prediction nor premonitory tremor occurred in Guatemala. The first wave of the earthquake was the strongest and most damaging.

If earthquake injury is to be diminished in the future, efforts will have to be directed toward the prevention of trauma caused by man-made structures. The major health consequences of earthquakes in Latin America consist not of the epidemics or famines that are overpopularized and relatively unimportant, but of the trauma that occurs within moments of the major quake. Good rapid epidemiological diagnosis of community problems elsewhere after a natural disaster would be useful in confirming this finding and in redirecting relief toward the more useful and more enduring development of aseismic housing. Also useful would be the recognition of the concept of prevention of earthquake-related mortality by government officials and by planners in public health and in urban and rural development. The enactment and enforcement of improved building codes and the education of the population in simple techniques of aseismic construction will have to become a first priority. Included in any code should be severe limitations on the use of adobe in this area as a housing material. This must be accompanied by further research in aseismic engineering, earthquake prediction, community education, and the epidemiology of disaster injury and its prevention.

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NEWS AND COMMENT

Auburn Dam: Earthquake Hazards Imperil $1-Billion Project

Since the collapse of the Teton Dam in Idaho in June 1976, the Bureau of Reclamation, builder of the Teton project, has been undergoing a time of trial. Its competence and credibility have been called into question, and two of its high officials have resigned under pressure. Furthermore, the bureau's troubles are by no means over yet. Now, its huge $1-billion Auburn Dam and reservoir project in California, on which more than $150 million already have been spent, may have to be abandoned because of earthquake hazards and a questionable choice of dam site and design.

The Auburn Dam would be built adjacent to the city of Auburn on the North Fork of the American River in the western foothills of the northern Sierra Nevada Mountains. Nearly 700 feet high and 4150 feet long, this thin arch, double curvature structure (curving gently from bottom to top as well as from side to side) would be the largest concrete dam of its kind in the world.

If the dam should suddenly collapse as the result of an earthquake—possibly one induced by the immense water pressures from the deep Auburn reservoir itself—the disaster that would ensue would be probably the greatest ever caused by the failure of a man-made structure. A 100-foot high wall of water would rush down the American River, washing out the bureau's Folsom Dam some 15 miles away, then descend rapidly upon metropolitan Sacramento, only 30 miles to the southeast of Auburn.

The lives of 750,000 persons would be imperiled, the California state capital would be wiped out, three military air bases would be destroyed, and several hundred thousand acres of rich farmland would be flooded. The potential economic losses are incalculable but would certainly run into the tens of billions of dollars.

Nobody can say what the probabilities are of such a disaster occurring if the dam is built as now designed. But state and federal officials have deemed them to be sufficiently great to delay awarding the main construction contract—thus far the only major construction work done has been for foundation preparation—pending further risk evaluation. In fact, Congress, which by and large has protested President Jimmy Carter's water projects "hit list," has itself concurred in the White House decision that the project should not go forward until it can be declared safe.

The Bureau of Reclamation is a 75-year-old agency which Westerners have properly esteemed for its role in helping bring prosperity to many formerly dusty cow towns and crossroads that would never have amounted to anything without development of life-giving water resources. But, since the Teton disaster,

the bureau's morale has been shaken, and for it to now lose the Auburn Dam project would indeed be bitterly discouraging.

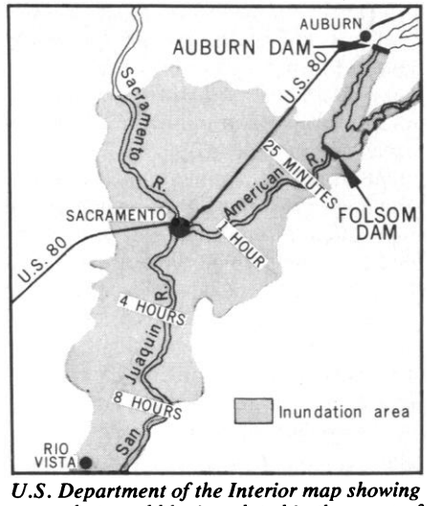
Some geologists have been awed at the extent of the bureau's current, if belated, efforts to investigate the seismic risks associated with the dam project, an investigation apparently being pressed in the hope that such hazards as are found can be made to yield to engineering solutions. Some 19 miles of trenches have been excavated by backhoe and bulldozer in and around the site to allow consulting scientists to try to piece together the site's geologic character and history. All told, the bureau will spend about $25 million on geologic investigations at the Auburn site, for, besides studies of seismic risk, extensive investigations have been made in an effort to ensure that the dam's foundations and abutments will not give way because of weak or fractured rock.

Construction of the Auburn Dam and the associated South Folsom Canal was authorized by Congress in 1965 as a major new feature of the Bureau of Reclamation's big Central Valley Project. From the beginning the Auburn project has enjoyed strong political support, although it met opposition in the early 1970's from environmental groups such as the Save the American River Association and the Environmental Defense Fund.

These groups challenged the project's economics and deplored the loss of 48 miles of free-flowing river above the dam and the fact that the flow of freshwater into San Francisco Bay and its biologically productive river deltas would be reduced. But their attacks against the project on such grounds held no promise of stopping it.

The project's sponsors included the state of California, all the county and municipal governments and water conservation districts in the Central Valley region, and several Californians of power and influence in Congress, such as Representative Harold T. (Biz) Johnson, now chairman of the House Committee on Public Works, and Representative John J. McFall, who until recently was the Democratic majority whip as well as a key member of the Committee on Appropriations. Expected to provide more water for farm irrigation and municipal use, plus 522 million kilowatt-hours of power annually and greater flood protection, the Auburn project has been deemed, whether rightly or wrongly, as one of great value to the Sacramento region and the Central Valley.

But the Sacramento *Bee*, an important

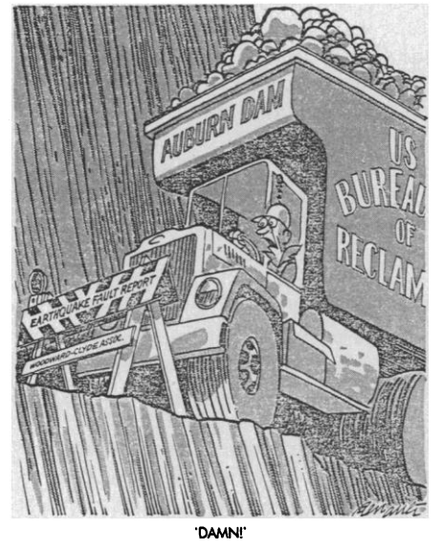


U.S. Department of the Interior map showing areas that would be inundated in the event of a total and instantaneous collapse of the proposed Auburn Dam.

editorial voice in the region, has probably reflected a change of public opinion to a more cautious view, as when it observed recently:

> We have always looked upon Auburn Dam as an essential project, of tremendous potential benefit to Northern California's growing water needs. We still do. Too many doubts remain, however. Californians, and especially those living in the path of the dam, need ironclad assurance of its safety before the federal government agrees to move ahead with it.

Here, one must understand that there are several basic types of dams, not all of which may be equally safe or economical for a particular site. The earthfill dam and the concrete "gravity" dam, both of which are roughly triangular in cross section and have a great bottom thickness, depend upon their sheer mass and weight to hold back the water and resist other stresses placed upon them. Then, there are the various kinds of concrete arch



'DAMN!'

dams, which, although differing in thickness and in other aspects of configuration, generally are alike in that the force of the water is directed primarily into the abutments. It is therefore critical to the strength of such dams that the abutments be built into strong, homogeneous rock that will not slip or give way.

A Bureau of Reclamation report issued in 1957 concluded that a site identified about a mile downstream from the present Auburn site was geologically satisfactory for the earthfill dam then under consideration. But none of the sites studied up to that time had been deemed favorable for a high concrete dam, and one of those examined was near the present site.

In any case, as late as 1965 the bureau still planned to build an earthfill structure. This plan was abandoned only after it was found that to obtain the necessary fill material some 5 to 7 square miles of land would have to be scalped of its overburden; given the amount of residential and industrial development already in the area, this was considered to be economically infeasible. So the bureau became committed to building a concrete arch dam.

The bureau's dam designers were sure that the rock conditions which earlier had made such a dam design seem unsuitable could be overcome. They proposed to remove all of the weak rock and use "dental concrete" to fill the resulting cavities, some of which were to turn out to be up to 100 feet deep.

The bureau recognized that the dam would have to be designed to withstand earthquakes, but at that time the principal hazard was considered to be the shaking the dam could receive from large distant events, perhaps occurring 100 miles away on the San Andreas fault or 50 miles away on the fault system on the eastern escarpment of the Sierras. The foothills province where the Auburn site is located was then known as a region of remarkably little seismicity, and, in particular, as one in which millions of years had gone by without any surface faulting—the kind of displacement which, if it occurred in the foundation or abutment rock of a concrete arch dam, could cause its collapse.

As a matter of fact, the seismic hazard issue really did not figure in the public debate over the Auburn project until 1975, when it emerged with a vengeance. Early that year, George C. Rouse, an engineer who had specialized in the study of dams under stress before he retired from the bureau in 1972, prepared a paper on the stability of the proposed dam, and—not satisfied with the bureau's re-

sponse to it—eventually sent a copy to California's Department of Water Resources. By summer, Rouse's views had been widely reported in the California press, and, in essence, what he said was that a thin arch dam may be appropriately built in a narrow canyon, say 2000 feet across, but not in a valley nearly a mile wide, such as the one at Auburn. Also, according to Rouse, the allowable stresses postulated in the dam's design were much too high, especially inasmuch as there was "practically no available information on the response of arch dams" to earthquakes.

Then, on 1 August 1975, an earthquake of 5.7 magnitude on the Richter scale occurred near the Oroville Dam, a large, earthfill structure which had been built by the state of California. It was 50 miles away from the Auburn site but in the same foothills province—and, to everyone's surprise, some surface faulting was found to have occurred, upsetting previous assumptions that all faults in this province were inactive. The Rouse critique and the Oroville quake (which did little damage to the earthfill dam) had combined to raise potentially explosive new issues about the Auburn project. Many Californians still remembered that, in the 6.5 magnitude San Fernando earthquake of 1971, an earthfill dam constructed by a local flood control district had nearly failed, jeopardizing the lives of 100,000 persons (defenders of the Auburn project like to point out that a small concrete arch dam situated right above the fault had survived the quake apparently undamaged).

In the fall of 1975, the Association of Engineering Geologists (AEG) established a seismic hazards committee, and the safety of the Auburn Dam became its first order of business. Donald C. Rose, a member of the committee from San Francisco who is certified as a structural engineer as well as an engineering geologist, reacted with disgust and alarm to a Bureau of Reclamation report in early 1976 on how the Auburn Dam would respond to what the bureau then considered the "maximum credible event."

This event was defined as a magnitude 8 earthquake 50 miles away, producing acceleration forces of a little more than one-tenth the force of gravity ($0.12g$) at the dam site. The report said that all "stresses and stability factors" had been found to fall within allowable limits, but, as Rose has told *Science*, he felt that this represented a "deliberate attempt to cover up the serious implications of the computer output."

From this data, he said, one could see that, even under the impact of the modest $0.12g$ earthquake shock, cracks extending more than 2000 feet horizontally and over 300 feet vertically would have

Briefing

A Pyrrhonian Sledgehammer

A new committee has been formed with a high ambition: to combat the public's propensity for belief in the supernatural. Targets of the committee's attentions range from astrology and parapsychology to faith healing, "life after death," flying saucers, chariots of the gods, astral projection, Atlantis, kirlian photography, exorcism, pyramid power, poltergeists, psychic plants, sasquatches (a.k.a. Bigfeet) and of course the Bermuda triangle.

The antimystic band is known as the Committee for the Scientific Investigation of Claims of the Paranormal, and the sword of its faith is a magazine called *The Zetetic*, the name given to the followers of the ancient Greek skeptic philosopher Pyrrho. Its first issue Pyrrholyzes scientology, Uri Geller, and biorhythms as predictors of batting averages.

Moving spirits behind the *Zetetic* and its committee are members of the humanist movement such as Paul Kurtz, philosophy professor of the State University of New York, and Lee Nisbet, executive editor of the *Humanist*. The humanists believe there is a resurgence of belief in the far out which must be reined in. "It's a very dangerous phenomenon, dangerous to science, dangerous to the basic fabric of our society," says Nisbet.

The rising tide of occultism is a symptom of the public's being "increasingly wishy-washy about the way it thinks about important issues. We feel it is the duty of the scientific community to show that these beliefs are utterly screwball," Nisbet declares.

In the humanist view, the public's infatuation with newfangled fads is being abetted by the media, particularly the *National Inquirer* and NBC. The *Zetetic* committee has filed complaint with the FCC that NBC showed documentaries on Bigfoot and the "Outer Space Connection" which presented them as true.

NBC has replied that the film "Bigfoot, the Mysterious Monster" was shown as part of the entertainment series "NBC Monday Night at the Movies."

Two years ago the *Humanist* sent to every newspaper in the United States and Canada a statement endorsed by 186 scientists affirming that there was no scientific basis for astrology. The current issue of the magazine records the regrettable fact that, despite the statement, "very few (if any) newspapers have dropped their astrology columns."

To communicate with Mars, converse with spirits, to report the behavior of the sea monster, describe the horoscope—all these, a poet from St. Louis, Missouri, has observed, "are usual pastimes and drugs, and features of the press: and always will be, some of them especially when there is distress of nations and perplexity, whether on the shores of Asia, or in the Edgware Road."

Common Censorship

The nature of totalitarian states is often as evident in their mundane actions as in their grosser modes of repression. The Soviet Union's habit of censorship, for example, is well reflected in the Russian edition of *Science*, a facsimile of the English edition but which lacks such items as the Glavlit censor deems seditious.

The censor's general rule of thumb is to cut any article that criticizes the inter-

appeared in the dam, on both faces and in some places going all the way through the structure. Even at that, according to Rose, the computer study had not taken into account some serious aggravating factors, such as the effect of aftershocks on the badly cracked dam.

(Glenn Tarbox, supervisory engineer of the concrete dams section at the Bureau of Reclamation's Engineering and Research Center in Denver, says that Rose overstates the case and that, in any event, the latest bureau studies indicate that only superficial fracturing would occur, with no deep cracking and no joints opening to leave free standing blocks.)

Public comments by Rose and other members of the AEG committee, together with the letter which the AEG sent to the bureau in April 1976 warning that the dam would be unsafe in even a moderate earthquake, all contributed to the growing atmosphere of suspicion and doubt surrounding the Auburn project. Also, the collapse of the Teton Dam, an earthfill structure later officially determined to have failed as the result of incompetent engineering on a poor site, made it clear that the bureau was anything but infallible. After this disaster, Gilbert G. Stamm, the commissioner of reclamation, and H. G. Arthur, director of design and construction, were in a clearly precarious position—and, once the Carter Administration took office, both resigned.

The seismic hazards issue continued to grow in intensity through 1976 and early 1977, with California state authorities such as the Seismic Safety Commission and the Department of Water Resources becoming very much involved. Ronald B. Robie, director of water resources, informed the bureau that his department simply could not support the Auburn project until satisfied that the dam was safe. And, in the opinion of acting state geologist Thomas Gay, the dam might be unsafe unless redesigned to withstand a powerful earthquake (magnitude 7) occurring within 5 miles of the site.

In addition, Harry R. Cedergren, a consulting engineer in Sacramento with wide experience in the designing of earthfill dams, gave the debate a new dimension by insisting that the rock at the Auburn site was not dependable or homogeneous enough for a thin arch concrete dam—a weakness which he indicated was beyond remedy. "One can only wonder if their extensive efforts to improve the Auburn foundations with dental concrete [some 300,000 cubic yards of it] will be any more effective than their extensive efforts to improve the Teton foundations with grout," he observed.

The issue took a dramatic turn when

nal policies of the Soviet Union or which compares it unfavorably with the United States. Of the 15 most recent available issues of the Russian edition, spanning a period from October 1976 to March 1977, seven have been censored, usually in the News and Comment, Letters, or Book Review sections.

In the 29 October 1976 issue, the censor took objection to the review of a biography of Edward Teller which made passing reference to Russian development of thermonuclear bombs. A news item in the 17 December issue about the imprisoned Russian biologist Sergei Kovalev was naturally blue-penciled: a more surprising excision was a story in the following week's issue chronicling repression of scientists by the right wing rulers of Argentina.

The censor felt his compatriots would be unable to handle the letters section of the 21 January 1977 issue. One letter discussed the Soviet civil defense effort; another announced the formation of a AAAS subcommittee on infringements of scientific freedom in foreign countries.

Russian readers of *Science* were not trusted to draw the right conclusions from a news story the following week about the CIA's estimates of the Soviet grain harvest. Nor were they judged mature enough to cope with a review in the 4 February issue of *Soviet-American Academic Exchanges, 1958–1975*. Several subsequent issues of *Science* contained no material threatening to the stability of the Soviet state until a profile of national security adviser Zbigniew Brzezinski on 11 March.

A curious feature of the censor's habits is the attempts he makes to hide his traces. There is an abashed half-heartedness about his actions which perfectly illustrates the saying that hypocrisy is the tribute vice pays to virtue. The censor does not like to leave vexatious white holes on the page and generally tries to cut an integral number of pages. Unfortunately this practice usually requires several innocent articles to be dropped along with the offensive item, which can make for a noticeable hiatus on the contents page. Regrettably, the censor does not trouble to reset the page in order to fill the gap. A more serious omission is the failure to repaginate: all of the Russian *Science*'s subscribers who can both count and read must be entirely aware of the censor's activities.

Cold Shower for Climatologists

A growing number of predictions, almost enough to constitute a fashion, have been made about disasters that could result from various perturbations of the climate. New ice ages, new drought ages, threats from the SST, threats from fluorocarbons—even the National Academy of Sciences joined the crowd with a recent report stating that the climatic effects of carbon dioxide release "may be the primary limiting factor on energy production from fossil fuels over the next few centuries."

All these are serious issues, but there is room for degrees of confidence in the various forecasts. A man who has little confidence in many forecasts is B. J. Mason, director of the English Meteorological Office. In an article in the 30 July *New Republic*, he lays into those who base their extrapolations on brief trends in a highly fluctuating record. Some scientists "unwisely predicted the onset of a new ice age" from the cooling trend in the Northern Hemisphere between 1940 and 1970; there are now signs that the trend has stopped. Other scientists interpreted the Sahelian drought years of 1970 to 1974 as evidence of a southward shift of the major climatic zones: it is now clear the zones moved slightly northward during the period, Mason avers.

Fluorocarbons may chew up the ozone layer and increase the flow of ultraviolet radiation but whatever the medical effects, the effects on climate will be "negligible and undetectable," and much the same is true of a fleet of Concordes, says Mason. As for the carbon dioxide effect, the atmosphere operates so many simultaneous mechanisms that the overall effect cannot be predicted and, in any case, may well be masked by natural variations.

Mason's moral: "The atmosphere is wont to make fools of those who do not show proper respect for its complexity and resilience."

Nicholas Wade

Research Status in DOE Looking Good

Many scientists are optimistic that a healthy prominence for basic research will be ensured by both the structure and leadership of the new Department of Energy (DOE), which was slated for final congressional passage on 2 August.

Much of the optimism is the result of a meeting on 14 July, arranged by presidential science adviser Frank Press, between Energy Secretary-to-be Schlesinger and a dozen or so scientist-administrators from universities and national laboratories. The meeting, held in the White House, was scheduled for 1 hour but lasted for 2, and the scientists emerged with the feeling that Schlesinger understood and shared their concerns.

All were impressed with Schlesinger's brains and openness. Louis Rosen of the Los Alamos Meson Factory thought he was "one of the most intelligent and one of the brightest people I have ever come in contact with." The meeting, he said, was "a very encouraging sign in terms of Dr. Schlesinger's perception of how basic research fits into his program. . . ." Richard Caldecott of the University of Minnesota was downright effusive. "I've been pretty down on the mediocrity we have had" in high government councils, he said, but contact with Schlesinger, Press, and National Science Foundation director Richard Atkinson made him feel "well, damn it all at least we've got a chance . . . we've got really superior intellects in those jobs. This guy Frank Press is really pretty special."

What has the scientists so pleased is that the DOE will have a high level "Office of Energy Research" that will coordinate R & D activities throughout the agency and, it is expected, will have programmatic responsibilities of its own in basic research. It is to be located in the Secretary's office and is to have a budget of its own, therefore avoiding the fate of those advisory bodies that are left to float off on their own, penniless and ineffectual, without links to the chain of command.

The existence of this office is, in large part, attributable to the efforts of academic scientists around the country who were anxious to see that research would not be trampled in the bustle of the new agency. Responding to approaches from the University of California and the Association of American Universities, Representative John Moss (D–Calif.), an enthusiastic fan of big science, introduced an amendment to the House DOE bill to establish an Office of Energy Research for administering the physical research program transferred from ERDA, as well as advising the secretary on R & D throughout the department. The House-Senate conference changed the office's duties from administering the ERDA program to advising the secretary on it. However, scientists are confident that the director will still be free to initiate research under a provision that allows the office to "carry out such additional duties . . . relating to basic and applied research . . . as the Secretary considers advantageous." They see the office as a device to ensure a sustained high-level focus on the country's long-range research needs, and also as a mechanism to support research that "falls between the cracks" of the agency's functions as well as long-range research in esoteric fields like theoretical thermodynamics.

Just how the office will work remains to be seen, because the legislation is designed, as Schlesinger wished, to leave a great deal to the discretion of the secretary. The law spells out 11 DOE "functions,"* to be overseen by eight assistant secretaries, but how these areas are combined under which secretaries is left up to Schlesigner.

Nonetheless, academic scientists think things are looking good. As a Moss aide says, "the science and R & D folks will have their inside person," and they are confident that the research office will have considerable influence if the right person is picked. And substantial good will was generated by the meeting put together by Press. Says a Press aide: "I guess this is one example of a science adviser quietly getting things done."—C.H.

*Energy resource applications; R & D; environment; international programs and policy; national security; intergovernmental policies and relations; competition and consumer affairs; nuclear waste management; conservation; power marketing functions; and public and congressional relations.

an internal memorandum prepared by nine geologists and seismologists at the U.S. Geological Survey (USGS) center at Menlo Park, California, was somehow leaked to the press on 20 March, the day before the Department of the Interior's water projects review team was to begin a hearing on the Auburn project. This memo, based on a brief field inspection of some trenches near the dam site, reported that less than a mile from the site a relatively young and presumably active fault had been found and that it "trends" toward the dam's right abutment.

Actually, the trenches examined by the USGS scientists had been part of a seismic risk evaluation commissioned by the Bureau of Reclamation almost a year earlier. For, after the Oroville quake had dispelled the belief that the foothills province was safe from surface faulting, the bureau had begun to rethink its past failure to submit the seismic hazards at Auburn to outside evaluation. The upshot was that, in the spring of 1976—and the bureau contends this was done of its own volition and not in response to pressure from its critics—the San Francisco consulting firm of Woodward-Clyde Associates was retained to make an exhaustive seismic study under a $1.5-million contract. About the same time, several other outside consultants were appointed to review the adequacy of the dam design in light of what might be learned of the earthquake hazard.

The findings of the Woodward-Clyde study, now virtually completed, were disclosed at a press conference in Sacramento on 28 June by Lloyd S. Cluff, the consultants' chief geologist. Although judgments as to what these findings meant for the future of the project were studiously avoided, it seemed clear that they were not encouraging. One conclusion was that, instead of the magnitude 5.5 earthquake hypothesized earlier as possible near the dam, there was evidence of active faults within 2 miles of the site that could produce an earthquake of magnitude 6 to 6.5. Such a quake would represent a "maximum credible event" for the dam designers much more powerful—and possibly more damaging—than the one that caused the extensive cracking in the 1976 computer study that had alarmed Donald Rose and the AEG.

As for the numerous faults that traverse the foundation itself, Cluff said there was somewhere between 1 chance in 10 to 1 in a 100 that there has been displacement on some of them within the last 100,000 years, which would make them "active" faults according to bureau criteria. Moreover, Cluff noted a

possibility that a sizable earthquake, of magnitude 5.7 to 6, could be induced at the dam site within the lifetime of the structure by the reservoir itself. He put the probability of this happening at only 2 to 5 percent if it is assumed that the Oroville earthquake was not induced by the reservoir there but at 30 to 50 percent if the assumption is that that quake was so induced. According to one theory, in an area already under seismic stress the weight of the water triggers the quake; according to another, the water pressure actually "lubricates" the fault and triggers displacement.

Another bureau consultant, Roy J. Shelmon and Associates, Inc., of Newport Beach, California, is engaged in what the bureau plainly regards as a critically important effort to determine conclusively, through age-dating studies, whether any faults within the foundation are in fact active. Yet, even if this study does conclude that these faults are inactive (and some bureau officials say they are confident that it will), some competent geologists will remain unconvinced, especially given the possibility that the filling of the reservoir could have an effect on very old and previously inactive faults and cause displacement.

If there is a significant division of professional opinion as to the potential for fault movement within the foundation or abutment rock, the dam project will probably be doomed, at least as now designed. After a visit to the dam site on 30 June, the Consulting Board for Earthquake Analysis which advises the state Department of Water Resources and its division of dam safety, stated:

> The board is particularly concerned with the critical effects of possible fault movements in the foundations or abutments. . . . The potentially damaging effect of such movements depend in large measure on the type of dam constructed and its ability to safely withstand deformations. Such deformations are likely to have more serious consequences for a concrete arch dam than for any other types of dams. . . . Thus, although a concrete dam might well be designed to withstand very high levels of shaking, it might fail as a result of small fault movements occurring in the foundation rock.

Although no earthquake could shake the faith that some Bureau of Reclamation engineers seem to have in the Auburn project as now designed, the bureau has conceded that it might have to abandon it. "We would not propose to go ahead with the same design if there were active faults in the foundation," Larry Von Thun, chief of the bureau's geotechnology section at the Research and Engineering Center, has said.

In such circumstances, Representative John McFall and other ardent sponsors of the project have indicated that they would switch to a different type of dam. But this might well prove impossible. If obtaining 63 million cubic yards of material necessary for an earthfill dam looked economically and environmentally unattractive 11 years ago, it is not going to look any better today.

Similarly, to switch to a concrete gravity design for so high and long a dam might be out of the question. The volumes of concrete required would be far greater and the cost of the project would go up accordingly (compared to the Auburn Dam, the bureau's Shasta Dam in California, a gravity-type structure, is 690 feet less in crest length and nearly 100 feet less in height, yet it contains more concrete). Any large cost increases associated with a design change could make the project unacceptable, especially inasmuch as Carter Administration reviewers already see the project as economically marginal.

The project's fate will probably be decided at the highest levels in Sacramento and Washington. The final decision may still be many months away, but the project seems caught in an inexorable chain of logic and events that ultimately will undermine it.—LUTHER J. CARTER

Game Theorist Morgenstern Dies

Oskar Morgenstern, 75, one of the most prominent scholars in modern mathematics and economics, died of cancer on 26 July. He was a co-founder of game theory as well as a progenitor of institutions: the Institute for Advanced Study in Vienna; the Center for Applied Economics at New York University (NYU); and, in 1959, Mathematica Inc., a private think tank which studies subjects such as the space shuttle, the negative income tax, welfare, and arms control.

Economics is often praised as the most successful of the social sciences, but Morgenstern was one of its most persistent critics. He frequently attacked the accuracy of the data that economists use as the basis for their models and forecasts. He charged that, while imitating the physical sciences in other ways, most economists have none of the physical scientist's respect for measurement and margins of error. For instance, in a 1975 speech he argued that the data errors that go into calculating the gross national product (GNP) are larger than the fluctuations in GNP that most economists find significant. Although Morgenstern was often out of step with his fellow economists, he began to be recognized by them toward the end of his life. For example, at a 1975 economics meeting, he was listed among the likely future winners of the Nobel prize.

However, Morgenstern will be remembered less for his work on economics than as the co-founder of game theory. This happened with the publication in 1944, with John von Neumann, of *Theory of Games and Economic Behavior*. Game theory considers situations in which there are several participants, no one of whom controls all the variables, and one of whom can be chance. The behavior of the participants will vary according to the strategies followed by others and by other factors, including psychology. Because game theory is so complex mathematically, it has attracted many mathematicians who have joined with people in other disciplines to apply the concept to social behavior, voting, military strategy, and other situations. Morgenstern's collaboration with von Neumann continued until the latter's death in 1957. It was one of the most successful partnerships in modern science, but it dogged Morgenstern too, to be always known as von Neumann's boy.

Like many prominent scientists of his generation, Morgenstern was a refugee from the Nazis. He was not Jewish, but his liberal political views made him *persona non grata* in his native Vienna after Hitler's invasion. He fled to the United States in 1938, to Princeton, for an appointment meant to be for 3 years, which lasted for 32. In 1970 he became a professor at New York University.

A curious element in his background was that his mother was an illegitimate daughter of the Austrian Emperor Frederick III. When the emperor learned that his gardener's daughter was going to have a baby by him, he conferred on the family a handsome settlement, which was later dissipated. Of such misfortunes, sometimes, are famous economists made.—D.S.