THE L.A. EARTHQUAKE SOURCEBOOK

Produced by
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designmatters
● Art Center College of Design

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Richard Koshalek
President, Art Center College of Design

HERE in Los Angeles, we live with the certainty that at any given time—and without any warning—the ground will shift dramatically. In the immediate aftermath, our infrastructure could be seriously compromised, with communication networks shut down and lifelines severed. In other words, the next major earthquake we experience stands the chance of becoming our Hurricane Katrina. The lesson of New Orleans is clear: In a mega-disaster, we may be on our own to ride out the initial mayhem that could follow. Yet, a post-Katrina scenario need not unfold in Los Angeles, because experts widely agree that we can mitigate the impact of the next big quake—if we plan ahead.

With **The Los Angeles Earthquake: Get Ready** project, Art Center College of Design has convened an innovative consortium charged with finding new solutions to this long-standing challenge. By bringing the visual and communication skills of the international design community together with expertise in science, emergency management, policy, and public health, this consortium is yielding entirely new, effective approaches to earthquake preparedness and safety. The clarity of the design approach is providing powerful ways to make new tools for preparation and coping available to the largest possible public.

THIS publication provides the first of these tools: an expertly designed, up-to-date reference resource on the topic at hand. While far from exhaustive, this compendium is the first to include truly diverse voices that together offer new wisdom about living along the web of faults that animate our active terrain. Various narratives and visual elements complement this core knowledge and raise fundamental questions that pertain to many aspects of contemporary existence. How do we deal with the need to prepare for something that has not happened in our lifetime? How do we fully realize that our personal actions—or inaction—will have real consequences? These and other provocative questions run through many of the book's essays, interviews, and profiles—with many answers as well.

AS much as anything, I hope that this publication and **The Los Angeles Earthquake** project will underscore the pivotal role of designers—and the entire creative community—in building public awareness and response to a major urban challenge that faces Los Angeles and numerous cities worldwide. Art Center is deeply committed to this kind of advocacy, and to expanding the range of socially relevant responsibilities for the creative individual. Through its educational mission, the College encourages students and faculty to develop original ways to engage with long-standing societal problems, and enables new generations of designers to collaborate with leaders in business, public policy, science, and technology.

BY creating new models for interaction and outreach, **The Los Angeles Earthquake** project also represents an exceptional opportunity for the media to carry an equally new message throughout Los Angeles and beyond. In this spirit of participation and optimism, therefore, Art Center dedicates this sourcebook to the media community. As the following pages show, we can all work together to get ready and move from a society in denial to a culture of possibility and individual responsibility—and in so doing, create an even more resilient city capable of transcending an enormous challenge.

Richard Koshalek
President, Art Center
College of Design

June 2008

Katherine Siy

PREFACE

Antonio R. Villaraigosa
Mayor, City of Los Angeles

ONE of the greatest things about Los Angeles has always been its resilience in the face of disaster. Unfortunately, because our landscape regularly subjects us to calamities such as wildfires, mudslides and earthquakes, that resilience has been called upon all too often. Yet every time a challenge arises, Angelenos are there to confront and overcome it in a way that perhaps no other city ever has. Our responders—from police and fire agencies to the many other vital community organizations that we rely on—step up and show the world how dedication and determination can save lives and inspire hope. Our people rise to the occasion with unparalleled support for their fellow citizens.

I have pledged to lead this city in facing its most daunting challenges. In Los Angeles, one of the biggest challenges we confront is preparedness for earthquakes. We always strive to give our responders the crucial resources they need, and as a result our emergency management capability is one of the strongest in the world. But as we've seen countless times in the past, it takes more than well-trained professionals to get us back on our collective feet after a disaster. It takes an unwavering commitment from our community. Our success in preparing for what we all know lies ahead—tomorrow or a decade down the road—should be a barometer of that commitment.

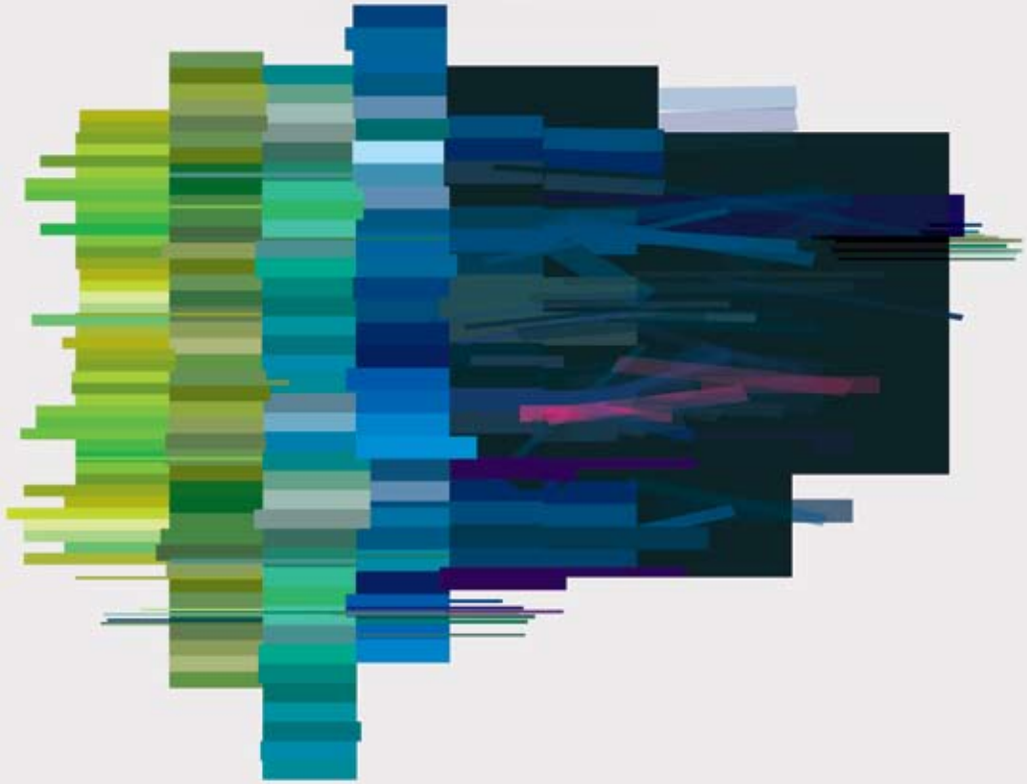
AS our responders stand as a model for other cities across the country and around the world, so can our citizens. We each have a role to play in mitigating the damage that will come in the wake of the next natural disaster.

This publication along with **The Los Angeles Earthquake: Get Ready** project serve as invaluable resources for developing the tools we need to face a future that is both certain and imprecise. Both of these efforts are led by Art Center College of Design, one of the world's top schools of design and art; their contribution reflects the pivotal role of the creative community in addressing major social issues. In addition, these efforts helped launch **The Great Southern California ShakeOut**, an unprecedented weeklong mobilization of public awareness throughout Los Angeles in November 2008.

BY bringing together authoritative expert voices with some of the talents who embody Los Angeles' great creative soul, these endeavors sound the call to action for each of us to work toward the common goal of building an even more resilient city. With community participation at their heart, these activities reflect my strong belief that solutions to our most pressing challenges are often found not only in government, but in the care we give to our neighbors and ourselves. On behalf of the City of Los Angeles, I am pleased to endorse this vital initiative.

Antonio R. Villaraigosa
Mayor, City of Los Angeles

Katherine Siy



INTRODUCTION

Mariana Amatullo

IN the wake of the devastation left after the landfall of Hurricane Katrina in August 2005, Richard Koshalek and I facilitated a compelling student-led investigation which took our small team to the crescent city for field research, six months after the storm. The project resulted in a set of innovative strategies for the urban renewal of New Orleans' ninth ward district. The sight of the hardest-hit neighborhoods, and our witnessing of the disheartening disruption brought about by the hurricane, and the man-made disaster that followed, ultimately became the inspiration for **The Los Angeles Earthquake: Get Ready** project.

Brenna Pribadi

IN setting the grounding framework for **The Los Angeles Earthquake** project, the key twist is that we are anticipating a natural disaster of catastrophic scale, instead of responding to one. Essentially, we want to be ahead of the possibility of a destructive quake—which all experts agree is inevitable. As a creative community, we are posing the questions: how do we act now before the big earthquake? And what can we do to lessen the impact after it occurs?

As a leader in art and design education, Art Center College of Design has a long-lasting tradition in shaping the form and function of our culture, producing creative leaders who bring purpose, utility, meaning, and pleasure to our daily lives. With **The Los Angeles Earthquake** project, the impetus for engaging students and faculty to think beyond the walls of the classroom fits into one of Art Center's primary missions as an advocate for the role of designers as change agents. It is also fully embodied College-wide in Designmatters, whose mandate it is to research and develop solutions to the critically relevant issues of our time. With the Designmatters imprimatur, **The Los Angeles Earthquake** project is conceived as a unique opportunity to position design education as a powerful catalyst that can bridge the divide between scientific understanding about damaging quakes, and the ability of the public to feel empowered and to change their behavior in terms of preparedness.

AS we immersed ourselves in the research phase of this project for the past three years, we have had an ongoing dialogue with scientists, emergency responders, and government officials who think about the implications of a major earthquake all the time. In this process, we were fortunate to align Art Center's efforts with the broadly supported initiative **The Great Southern California ShakeOut**, a week of special events in November 2008 featuring the largest public preparedness drill in the U.S. history, and an unparalleled number of activities organized to inspire Southern Californians to get ready for a potentially enormous earthquake in our future. The basis for this effort is the **ShakeOut** scenario, which models a probable 7.8 magnitude earthquake on the southernmost segment of the San Andreas Fault, identifying physical damages, and estimating in great detail the cascading social and economic consequences of such an event. Perhaps the most striking aspect of this comprehensive scientific study, led by Dr. Lucile Jones of the U.S. Geological Survey with over three hundred contributors, is that it depicts an earthquake no Californians (except the handful survivors from the 1906 San Francisco quake) have ever experienced before—a disaster causing widespread damage regionally, and precipitating a level of systemic disruption that our communities are ill-prepared to face.

WHETHER the earthquake modeled in the **ShakeOut** scenario ever happens, the scientific consensus is that a quake of a similar magnitude is highly plausible in our lifetime. It is not a matter of if, but when, and innovative communication strategies that overcome barriers to preparedness and can improve upon individual and collective resiliency are critically needed.

TIME and again in the development of **The Los Angeles Earthquake** project, we heard from our partners that there is a weak link—getting people to pay attention to readiness. We thought hard about these issues. Very early on we seized on what Art Center's most powerful role and window of opportunity for a lasting contribution could be: devising a multimedia communication strategy to make people more aware of what could actually happen and how they could be better prepared. We viewed this project as an invitation to explore new communication vehicles to get important messages out. The diverse mosaic of the City of Los Angeles has challenged us to search for culturally appropriate means for outreach that can resonate at a grassroots level with some of the most under-served populations who will be at great risk during a catastrophic event. Our contemporary digital context and the explosion of participatory media platforms and social networks are also channels for learning and civic engagement that we are tapping into with the conviction that we can foster an unprecedented level of production and distribution of ideas that may galvanize

the public to engage in preparedness as a matter of lifestyle and informed choice. The new paradigms for communication created by the project aspire to provide a blueprint as well for vitally needed mitigation efforts beyond California, as the recent disasters of Myanmar and Chengdu attest. With a series of three interrelated components, this visual sourcebook, a public awareness campaign, and a civic event, "The Get Ready Rally"—**The Los Angeles Earthquake:Get Ready** project launches during **ShakeOut** week with the promise of starting a new conversation.

IN many ways, this publication represents the foundational platform and repository of knowledge for the project. The diversity and depth of testimonials, interviews, and essays captured in the following pages underscore our multifaceted learning, one that embodies the celebrated edict by H. G. Wells: "the history of humanity is a race between learning and disaster." I trust that our journey will live on through the compelling messaging, images, and media created by the students and faculty of Art Center College of Design—a vital laboratory for design education and leadership.

Mariana Amatullo
Vice President,
International Initiatives
Director, Designmatters
Director, The Los Angeles
Earthquake: Get Ready Project
Art Center College of Design

SECTION 1:
STORIES FROM THE FAULT ZONE

LONG AGO, when most of the world was water, Great Spirit decided to make a beautiful land with lakes and rivers, that turtles carried on their backs. One day the turtles began to argue and three of the turtles began to swim east, while the other three swam west. The earth shook! It cracked with a loud noise. The turtles could not swim far, because the land on their backs was heavy. When they saw that they could not swim far away they stopped arguing and made up. But every once in a while, the turtles that hold up California argue again, and each time they do, the earth shakes.

–Legend of the Gabrielino Indians, Southern California

HERE at the edge of the North American tectonic plate, we can count on earthquakes. We may not be able to pinpoint when they will happen, we just know that they will, at regular intervals, and occasionally with enough force to raise mountains and collapse bridges. We know as we put up our buildings that we must build them to stronger standards than they do in the places where segments of the earth never collide and slip apart; we know as we deliberate over where to hang a heavy painting that we can't nail it to the wall over our beds. We are aware that sometimes a force pushes us out of our chairs when there's no one in the room.

IF you look at a tectonic map of the world, you can see why this is true. All along the west coast of our continent, our North American plate forms an uneasy boundary with the Pacific plate, which reaches all the way to the Marianas Trench, just east of Japan. For tens of millions of years, these plates have been sliding past one another, straining at their edges into millions of fissures. We call these fissures "faults," and we build our cities on top of them. Sometimes we don't know they're there until, for some unknown reason, a fault rips open like a seam—a few inches, a few feet, or a mile. Then we name them: Newport-Inglewood (6.4 at Long Beach, 1933). San Fernando (6.7 near Sylmar, 1971). San Andreas (8.0 near Fort Tejon, 1857, among others).

There's the lamp that flies across the room in the pre-dawn darkness; the pets that wake their owners mere seconds before; the neighbors who spend the last few jolts shivering naked in the street.

In the days that follow an earthquake, hardly anything satisfies the survivors better than trading narratives about those shattering seconds when the faults give way. This has been true for as long as humans have walked on this unsettled ground: As geologist and author Susan Hough has noted, the world's most vivid petroglyphs can be found alongside faults. Perhaps to describe the trembling of the earth and the tumbling of rocks, the earliest residents of the fault-ridden Mojave Desert drew zigzag lines on rock faces. Tales of canyon-dwelling monsters imagined and passed down by the early Cahuilla Indians near Palm Springs were probably inspired by a great earthquake on the southern San Andreas Fault, sometime around 1675, give or take 30 years. Two centuries later, in San Francisco, Mark Twain observed that first-hand accounts of the 1865 earthquake "made toothsome gossip for nine days."

TWAIN told of women running down streets holding naked children by the ankles, men fleeing barbershops half-shaved, confused dogs scrambling up attic ladders. Our stories today—many of which get repeated with slight variations after every temblor—are hardly much different. There's the lamp that flies across the room in the pre-dawn darkness; the pets that wake their owners mere seconds before; the neighbors who spend the last few jolts shivering naked in the street. We praise our luck, and vow to do better next time. Fill the water jars, secure the toppling bookcase that missed the bed by just a few inches, bolt down the toilet that came unmoored and floated straight out of the bathroom. Maybe we even invest in pajamas.

Yet those nine days of gossip turn into nine months, and then nine years, and finally, the stories stop circulating. A few might crop up on the 10th anniversary, but by then, embellished and distilled by time, they have begun to sound like someone else's stories. We move into new apartments, forgetting to inspect the integrity of their foundations. We neglect to keep a wrench near the gas shutoff valve, or even to investigate where that valve is. One lazy day, we find all our canned goods expired, throw them out, and move on. With bills to pay, children to feed, and deadlines to meet, we worry only about preparing for tomorrow. We rarely consider that tomorrow might bring an earthquake.

This book is meant to serve as a reminder that tomorrow is as likely a day as any. Unlike hurricanes, earthquakes don't have a season. All weather is earthquake weather.

As **The L.A. Earthquake Sourcebook** came together in the spring and summer of 2008, the ground in California had been relatively still for an awfully long

time; a 4.0 that rattled San Bernardino on June 23, 2008, seemed like big news. Indeed, although nearly half of California's residents live near enough to the southern San Andreas Fault to be affected by a major rupture there, a great many of them have never felt a significant earthquake at all. There is no way to know whether the quiet will hold as the book makes its way through the production process. It's possible that you have already felt the little earthquake that reminded you to replace the batteries in the flashlight you keep under the bed, and made you grateful you spent the relatively small sum it cost to get reinforce the foundation of your home, if you have one.

IT'S also possible that some segment of Southern California currently lies in ruins, in which case this book will be, well, interesting.

But if none of our faults have moved enough to remind you what lies beneath us, consider this book a benign, metaphorical earthquake. In tandem with the U.S. Geological Survey's mock earthquake drill, **The Great Southern California ShakeOut**, scheduled for November 12-16, 2008, this book has been designed to give residents, local decision makers, and media in this quake-prone land the basic tools to prevent a disaster from turning into a catastrophe.

Because the best way to combat fear is with knowledge, **The L.A. Earthquake Sourcebook** begins with a primer in the science of earthquakes. Susan Hough, who is also Scientist-in-Charge at the Pasadena (California) Office of the U.S. Geological Survey (USGS) and the author of the 2006 biography of *Charles F. Richter, Richter's Scale: Measure of an Earthquake, Measure of a Man,* gives the history of that science, from the 1906 San Francisco earthquake to the modern era of networked instruments that record many a seismological event and instantly transmit its magnitude back to a lab. Thomas Jordan, the director of the Southern California Earthquake Center at the University of Southern California, explains why after many decades of trying geologists have yet to accurately predict an earthquake. And in a profile of Lucy Jones, the USGS chief scientist currently in charge of the agency's Multi-Hazards Demonstration Project, gives an introduction to the developing science of paleoseismology, by which geologists can determine with increasing precision when a given fault last broke, and how hard it shook. It's because of refinements in paleoseismology that researchers know that an earthquake on the southern San Andreas Fault is long overdue. "[W]e think this is an earthquake," Jones says, "that everybody should be ready for."

Kevin Wong

Chieh Ni Chu

EARTHQUAKE EXPLORATIONS IN SOUTHERN CALIFORNIA

Susan Hough

WAY BACK IN 132 A.C.E., the Chinese astronomer Zhang Heng invented an instrument with which to detect earthquakes. A bronze vase adorned with eight slender dragons, the instrument would respond to a disturbance in the earth by dropping a ball from the mouth of a dragon into a bronze toad below. Zhang's instrument was sensitive enough to detect an earthquake 400 miles away, but it would take nearly two millennia before scientists began to understand the tectonic forces that cause temblors, and developed an instrument, the Wood-Anderson seismograph, to measure their force.

LATER, IN 1935, Charles F. Richter devised a mathematical formula to help scientists compare the relative size of earthquakes. The Richter scale is the basis for the moment magnitude scale seismologists currently use to evaluate earthquakes.

THE SCIENTIST-IN-CHARGE at the Pasadena Office of the U.S. Geological Survey, **Susan Hough** writes about earthquakes as keenly as she studies them, with curiosity and passion to inspire lay readers. Among her many books and articles is the 2007 biography of Richter, *Richter's Scale: Measure of an Earthquake, Measure of a Man*. In the following essay, she gives an introduction to the basic precepts of seismology, and the geologists who developed the science.

YOU don't have to spend a lot of time in California to know that this is earthquake country. When Captain Gaspar de Portola led his expedition into the state in 1769, a moderate earthquake greeted him and his men as they camped near a river in the southland. Santa Ana de los Temblores, they called it. Earthquakes continued to rattle settlers who poured into Northern California after James Marshall found glittery nuggets along the American River. Awareness of and concern about earthquakes climaxed with the great San Francisco earthquake of 1906, which focused both the world's and the geological community's attentions on California.

Scientists began investigating earthquakes with modern instrumentation in the late 19th century, but the field of seismology arguably came of age with the 1906 earthquake. Data collected in its aftermath led directly to one of the most basic tenets in earthquake science: elastic rebound, which explains how earthquakes happen as a consequence of stress accumulation. Perhaps the most impressive post-earthquake investigation was one done in relative obscurity. Geologists followed not only the fresh scar left locally by the 1906 earthquake, but continued through Central and Southern California, eventually mapping nearly the full extent of the San Andreas Fault.

IN Los Angeles, burgeoning business interests sprang into action, painting the region as blissfully free of all natural hazards, including earthquakes. Yes, faults had been mapped in the Los Angeles area, but through the 1920s at least some geologists described them as ancient and harmless relics (including the Newport-Inglewood Fault, which produced the 1933 Long Beach earthquake). The San Andreas Fault, when acknowledged at all, was dismissed as being too far from the city to be of concern.

The best scientific minds of the day knew better. Even then, the far less expansive Los Angeles was not so far away from the San Andreas Fault. Scientists, among them Harry Oscar Wood, knew that a large earthquake had occurred on a southern stretch of the San Andreas Fault in 1857, and that large quakes would inevitably happen again.

In a 1916 article, Wood laid out an innovative blueprint for a network of seismic stations throughout the state, and made a strategic suggestion that the plan be tested on a limited scale in Southern California. By 1921, Wood had convinced the Carnegie Institute to underwrite a first-ever seismological laboratory in Southern California. The lab was set up under Wood's direction, occupying borrowed space at Mt. Wilson Observatory.

WOOD teamed up with astronomer John Anderson to design a new breed of seismometer. Unlike the ungainly earlier instruments that recorded large global earthquakes, the Wood-Anderson seismometer was a marvel: small, light, relatively portable, and able to record small local rumblings. In Anderson's words, "There ain't no other seismograph worth talking about than ours." The first Wood-Anderson seismometer was installed at Mt. Wilson.

Through its first five years, Wood's laboratory remained under the auspices of the Carnegie Institute, and independent of Caltech, which had been founded as a scientific institute only in 1920, and added a degree program in geology only in 1925. As the lab outgrew its space, Wood convinced the Carnegie Institute to underwrite the costs of new quarters. Dubbed the Kresge Lab in honor of one of its benefactors, the building was constructed in a residential area in Pasadena a few miles from the Caltech campus.

In 1927, a nascent Southern California seismic network comprised six stations, sparse by today's standards but sufficient to record small earthquakes throughout the region. The network's first permanent station was installed at Kresge (where it remained in operation until it was moved to the campus of Art Center College of Design in 2006).

As the seismic network began producing data—seismograms recorded on film—Wood recognized the need for an analyst with a background in physics. He approached Caltech

Earthquake country and the Golden State. From the beginning, as now, they are one and the same.

head Robert Millikan, who suggested a young man who had just earned one of Caltech's earliest Ph.Ds in physics: Charles Frances Richter. Richter accepted Wood's offer, intending to work at the lab only until he could find a more suitable position in his field.

IN the meantime, Millikan had developed a keen interest in the seismological laboratory and seismic network, which he recognized as potential world-class research resources. Millikan decided that an infusion of world-class seismological expertise was needed to fully exploit data from the network. In 1929, Caltech hosted an international gathering of the world's leading experts in seismology. Among the attendees was German-born Beno Gutenberg, renowned for his contributions to global seismology. Millikan extended a job offer to Gutenberg, who joined the Caltech faculty in 1930.

AT Caltech, Gutenberg initially focused on global earthquake studies while Richter continued to analyze local earthquakes recorded on Wood-Anderson instruments. Richter's early efforts focused on development of the first-ever scale to rank the size of earthquakes in Southern California, the scale that eventually turned his name into a household word. Soon thereafter, Gutenberg teamed with Richter to expand the original formulation to measure the size of earthquakes in other locations, and to measure more accurately the magnitudes of large earthquakes.

The Seismological Laboratory continued as a Carnegie-Caltech partnership until the mid-1930s. In 1937, Caltech formally took over operations of the lab, and both Richter and his colleague Hugo Benioff joined the Caltech faculty. Only Wood, who did not hold a PhD, remained on the Carnegie payroll. Caltech continued to run the seismic network, which expanded to 20 stations by 1970. In the 1970s, the network began operations as a partnership with the U.S. Geological Survey. The number of stations increased to 148 by 1976 and began to transmit data via telemetry rather than relying on local film recording. Today's network of over 350 stations is a far cry from the fledging network of the 1920s, but continues to reflect its heritage as a state-of-the-art research resource that not only serves societal needs, but also drives modern earthquake science.

Earthquake country and the Golden State. From the beginning, as now, they are one and the same.

Clifford Elbl

THE "P-WORD"

Thomas H. Jordan

IF WE KNOW SO MUCH about faults, why can't we predict earthquakes? The question baffles even scientists, who continue to seek the formula that will allow them to pinpoint the size and location of the next big earthquake. **Thomas H. Jordan** is the Director, Southern California Earthquake Center, University of Southern California, where he also serves as professor and William M. Keck Foundation Chair in Geological Sciences. He describes himself as optimistic about the future of earthquake prediction, considering it "an important gauge of progress in earthquake system science."

WE know a lot about earthquakes: where faults might rupture to produce earthquakes, how big these ruptures can get, and how frequently (on average) they will occur. But we cannot predict with any useful precision when a large earthquake on a particular fault will actually happen.

Not that we haven't tried! For more than a century, seismologists have deployed sensitive instruments around faults in search of signals that could reliably warn communities of impending disasters hours to weeks in advance. By the 1970s, many believed this type of short-term earthquake prediction was right around the corner. A panel of scientists convened by the National Academy of Sciences in 1976 issued a very optimistic assessment:

"Reliable earthquake prediction is an achievable goal. We will probably predict an earthquake of at least magnitude 5 in California *within the next five years* in a scientifically sound way and with a sufficiently small space and time uncertainty to allow public acceptance and *effective response*." [emphasis added]

Thirty years later, this promise remains unfulfilled. Though various schemes for short-term prediction have been proposed, none has proven successful, despite the substantial advances in instrumentation for monitoring active faults.

Confronted with these faiures, many experts have become so discouraged that they refrain from using the "P-word" in public, and research has faltered. Some have even advocated abandoning the subject altogether, arguing that the pursuit of prediction is a wild goose chase that distracts us from the real task at hand: making sure our buildings remain safe during the temblors that are certain to shake California in the not-too-distant future.

The inability to predict earthquakes demostrates how little we really know about the processes of seismic faulting. The predictability of earthquake phenomena is thus an important gauge of progress in earthquake system science.

SUCH reactions are unscientific and impractical, however. Seismic safety depends on long-term forecasting—predicting earthquakes on time scales of decades to centuries. The U.S. Geological Survey incorporates detailed long-term forecasts for all 50 states into its official National Seismic Hazard Map, on which the building codes in California and most other seismically active states are based. Insurance companies use even more sophisticated forecasts to set their policy premiums. Research aimed at predicting seismic activity on shorter time scales is critical to testing these long-term forecasts, which cannot be directly verified without waiting for a very long time.

Prediction research is also motivated by the search for fundamental scientific knowledge. The natural systems that govern our environment are extremely complex, and our success in predicting their behavior is the way we measure our understanding of these systems. The inability to predict earthquakes demonstrates how little we really know about the processes of seismic faulting. The predictability of earthquake phenomena is thus an important gauge of progress in earthquake system science.

Why is earthquake prediction such a difficult problem?

Rocks are very brittle; they fracture suddenly, starting on a tiny patch of fault about the size of a living-room rug. Most stop soon after they begin, producing only small earthquakes. In rare cases, the fracture continues to propagate along the fault, like a crack through glass, at speeds up to 6,000 miles per hour. Magnitude 2 events (which are usually too weak to be felt) are 10,000 times more common than magnitude 6 events (which can damage buildings), yet they appear to begin the same way.

In Southern California, seismometers record at least several magnitude 2 events every day. Therefore, predicting destrutive earthquakes depends more on knowing

when the rupture will stop than when it will begin. Because slight variations can make a big difference—fracturing is whwat physicists call a chaotic process—predicting the evolution of any particular fracture is essentially impossible, even if you could accurately measure in advance the properties of the rock masses on either side of the fault—which, of course, you can't.

MOST ruptures in California begin three to 12 miles below the surface, and the opaque rock that separates them from our surface instruments precludes remote sensing using radar or other electromagnetic waves. (Seismologists really envy meteorologists, who can simply watch hurricanes and tornados as they form and then move leisurely through the atmosphere!) Direct sampling by drilling is technically possible, at least in the uppermost part of the seismogenic zone, but it's prohibitively expensive. An experimental drill hole near Parkfield, California, has recently probed the San Andreas Fault at depths reaching two miles, but the total cost of the project was almost $30 million.

The prediction problem involves not just mapping the properties of rocks around the fault zones, but also the forces that cause the faults to snap. We know these forces are increasing as the motions between the Pacific and North American plates distort the tectonic blocks on either side of the San Andreas Fault, and we can measure the distortion using GPS satellites. The rate of plate motion, about two inches per year, creates enough distortion to generate earthquakes of magnitude 7.5 to 8.0 every 150 years or so. However, the interval between such events is highly irregular; geologic data on past ruptures indicate it can be as short as 75 years and sometimes greater than 300. For instance, the southernmost section of the San Andreas, from San Bernardino to the Salton Sea, hasn't broken in a big earthquake since around 1690; seismologists nervously joke about the region being "10 months pregnant."

The irregularity of earthquake sequences stems primarily from the complexity of fault systems. Although the San Andreas is the master fault of the plate boundary, it is flanked on either side by a host of active, subsidiary faults—over 300 in Southern California alone—many capable of large events. In fact, all of the destructive Southern California earthquakes during the last century were generated by slippage on these subsidiary faults rather than on the San Andreas itself.

FAULTS interact with each other through earthquakes: when one fault slips, it changes the forces on others faults in its neighborhood and thus modifies the time when its neighbors are ready to slip again. Moreover, one earthquake can trigger others, leading to chain reactions. When a main shock triggers a bunch of smaller earthquakes, we call them aftershocks. "Foreshock" is just a term we use to describe an initial event that happens to be followed by an aftershock bigger than itself. To our frustration, foreshocks don't seem to have special properties that tell us a big one is on its way. Indeed, the "chatter" of earthquakes, big and small, constitutes a conversation among faults we don't yet understand.

Is the quest for earthquake prediction hopeless?

Many seismologists are pessimistic that the P-word will ever prove useful in helping society reduce earthquake risk, but I am personally more optimistic. The predictability of seismic activity can be observed on many time scales. For instance, simple statistical rules of earthquake triggering can describe the short-term behavior of aftershock sequences, such as the regular decay in aftershock frequency with time, and these rules are already being employed to create an official daily earthquake forecast for California.

Scientists are now developing computer models that chart how tectonic stresses build up within the fault system and how a rupture on one fault segment changes the stress throughout the surrounding region.

Depending on the geometry of the fault network, such stress changes can either increase or decrease the likelihood of earthquakes on nearby fault segments, which helps to explain the variability in earthquake recurrence intervals. To capture the physical and geometrical effects, the fault-system models must be very complex (much like the climate-system models being developed to predict global warming), but improving them will help reduce the uncertainties in long-term earthquake forecasting.

But monitoring how stress build-up and release change the regional pattern of earthquake occurrence, scientists might be able to predict earthquakes over time intervals as short as a few years or maybe even a few months, although with substantial uncertainties. The basic idea is that stress variations can raise or lower the frequency of small earthquakes, and the events recorded on networks of seismographs can therefore provide a regional stress gauge. Someday you might hear a news report that says, "The National Earthquake Prediction Evaluation Council estimates that, during the next year, there is a 50% probability of a magnitude 7 or larger earthquake on the southernmost segment of the San Andreas Fault." Much current research aims to establish a scientific basis for this type of intermediate-term prediction.

How should society respond to a threat that is neither imminent nor long-term? An intermediate-term prediction would give the probability of an event only on time scales of months to years.

But what effect would credible predictions have on property values, insurance rates, health care premiums, and other investments in the threatened region? Since false alarms would likely be common, how would communities deal with this uncertainty? How should society respond to a threat that is neither imminent nor long-term? An intermediate-term prediction would give the probability of an event only on time scales of months to years; not precise enough information to warrant expensive and disruptive measures (such as large-scale evacuations) to mitigate earthquake damage.

It seems clear that although the pursuit of earthquake predictions is a valuable one, the ability to ultimately issue such predictions would raise very difficult questions, both for scientists and for policy makers. ♂

AN EERIE QUIET ON THE SOUTHERN SAN ANDREAS

A Profile of Lucy Jones
by Judith Lewis

SINCE SHE APPEARED on television after the 5.9 magnitude Palm Springs earthquake of 1986, **Lucy Jones** has been calming the post-quake public with her assured explanations of seismic events. After the Landers and Joshua Tree events of 1992 (7.3 and 6.2, respectively), she earned the title of "earthquake mom" for appearing on television with her toddler son in tow. She is now chief scientist for the USGS Multi-Hazards Demonstration Project in Southern California, where she coordinates the efforts of a multidisciplinary team to understand natural hazards and their consequences.

Ahjung Baik

IN 1974, a graduate student in geology named Kerry Sieh led a team of researchers to a marshy piece of land along the southern San Andreas Fault where they cut a slice into the earth to map the upheavals of geologic time. By digging trenches to expose layers of sedimentary deposits, Sieh and his colleagues were able to observe offsets in the soil consistent with earthquakes, collect samples of earth at the sites of those disruptions and, through a process known as carbon-14 dating, determine when the earth last moved. Sieh's experiment at Pallet Creek, on the south-central reach of the San Andreas fault near Palmdale, California, would forever change the way geologists charted ancient earthquakes, and Sieh was dubbed the father of a new field of science: paleoseismology.

Sitting in her office at the U.S. Geologic Survey on the campus of the California Institute of Technology some 34 years after Sieh's landmark dig, seismologist Lucy Jones uses sheets of paper and magazines to demonstrate the science of paleoseismology. With each sheet representing a layer of sediment, she shows how geologists excavate a site and look for evidence of seismic shifts. She begins by laying one sheet on her desk, which she partially covers with two more sheets set side by side across the first.

"SAY you've got a fault," she explains, "and there's a shift along the fault." She moves the top two pieces of paper until she exposes a sliver of the bottom layer. "And now another flood comes through, and you get another layer of sediment." Two more pieces get laid down, slightly askew relative to the stack. "And you can see that the one on top is broken in a different way than the one below.

"Now we go and put in something else,"—she sets a magazine horizontally across both piles of paper, covering the seam between them—"and this layer hasn't broken yet.

"You date this layer," she says, tapping the magazine on top, "and you know the earthquake happened sometime before that." Then she pulls out the paper on the bottom. "And you date this layer, knowing that the earthquake happened after it got deposited. Now you've bracketed the time of the earthquake by dating the layers of sediment that weren't disrupted." Next you date the layer that was disrupted, and there you have it: a historical record of an earthquake.

"Geologists working on the fault refer to it as being 10 months pregnant," Jones says. "But I would argue that it's actually more like being 20 months pregnant, at which point you know you're not dealing with a normal pregnancy.

There are just a few problems with paleoseismology, at least as it applies to dating earthquakes in Southern California. Sieh was able to pull off his Pallet Creek experiment so elegantly because he had found a spot where the fault ran through a classic marsh, where floods and fires laid down carbon-rich peat and charcoal at regular intervals. But the segment of the San Andreas that remains most mysterious to modern geologists, the eerily quiet southern extreme that most directly threatens the Los Angeles metropolitan area, runs almost entirely through a desert.

"Usually you figure out how active a fault is by finding features that have been offset by the fault and can be dated," Jones explains. "Datable features usually involve water. There isn't very much water [through this section of the fault]. And it's very difficult to find features that have been offset that have been accurately correlated across the fault."

JONES stresses that she's neither a field geologist nor paleoseismologist herself. "I'd need to be led by the hand into the field by another scientist to do that kind of research," she says. Instead, she has focused her career for nearly three decades on probability assessments for earthquakes, developing equations to predict how one earthquake triggers another. For many years she

Think about the seven days after Katrina—the images of people dying, people thirsty and waiting to be rescued on the roofs of their houses—keep that image in your head. Now let's talk about the earthquake in Southern California. There are things you have to see to believe.

served as the scientist-in-charge for the U.S. Geological Survey's Southern California earthquake program, where she was instrumental in developing a Web site to determine the probability of an earthquake within 24 hours. "It's on the basis of that research that the state issued its first earthquake warnings," she says.

But at 52, with over half her life invested in earthquake probability, Jones made a decision to expand beyond her own research, and set her sights on coordinating a larger effort; a collaboration among USGS scientists, universities, government agencies, private companies and emergency responders to improve community resiliency to natural disasters. She drew up a proposal for such a project in the summer of 2005, and it landed before the President's office of management and budget two weeks after Hurricane Katrina laid waste to the Gulf Coast. By the spring of 2007, the Multi-Hazards Demonstration Project in Southern California had been fully funded by Congress, with a quarter of a million dollars devoted to the earthquake portion.

"Twenty years ago there was more dismissal of what we were saying," Jones recalls. "But this time we said to people, 'Think about the seven days after Katrina—the images of people dying, people thirsty and waiting to be rescued on the roofs of their houses—keep that image in your head. Now let's talk about the earthquake in Southern California.' There are things you have to see to believe."

The Multi-Hazards Demonstration Project will confront the consequences of several potential Los Angeles disaster scenarios: floods, fires, landslides, and earthquakes. But the project's first wave of funding will be devoted to a paleoseimology project: the "Southern San Andreas Fault Evaluation" (SoSAFE), an investigation into that once-active segment of fault that has remained mysteriously silent for the last 330 years.

"It seems insane," Jones says, "but we actually don't have a good fix on the southernmost part of the fault. We know it's been 300 years since the last earthquake. Is that because they only happen every three hundred or five hundred years, unlike up north where it's pretty clear that they happen every 150 years? Or is it that we're overdue? And what does it mean that we're overdue?"

AS a point of departure, the team Jones has assembled for SoSAFE will examine a "probable" earthquake on the southern San Andreas: a rupture that begins near the Salton Sea and continues roughly 200 miles north past Palmdale to Lake Hughes. Because faults send out concentric circles of energy at each point of rupture as they rip, a rupture moving toward the city of Los Angeles will hurt more than one moving away. Because the length of the rupture determines the size of the quake, "we're modeling it at 7.8," says Jones. And because the magnitude of a quake determines its duration, she predicts that, in a 7.8 quake that ruptures along 200 miles of fault, "the ground will shake for 100 seconds."

To indicate SoSafe's area of focus, Jones takes another piece of paper and draws a six-inch line, like a flattened S, marking points along it to represent the sites where trenches have been dug and rupture chronologies have been recorded. "We know that the 1857 Fort Tejon earthquake went from Parkfield to the Cajon Pass," she says, assigning a dot to Parkfield at the top of the S and another roughly halfway down. "At Pallet Creek, Kerry's original site"—she marks a point between Palmdale and the Cajon Pass—"we have the last 11 earthquakes, and we have times for all of them. At Wrightwood," precisely halfway down the map, "we have the most complete earthquake history we have anywhere—30 earthquakes. But down here," where the fault reaches toward the Salton Sea, "we only know for certain that we had an earthquake

in 1680 that broke in three places." She marks three dots on the lower third of her line. "And for a long time, we didn't have any data beyond that.

"Now we have new trenches being dug," and new dating techniques such as thermoluminescence—a way of measuring how long soil has been exposed to sunlight—to help pinpoint the age of ruptured soil. And despite the dearth of datable features, "we've been able to determine that there were probably six earthquakes between 800 A.D. and 1680 A.D," an average of one every 150 years.

"Now that we have evidence that there really have been a lot of earthquakes on the Coachella Valley segment," Jones says, "we've changed the way we talk about it. We used to be a lot more cautious. We used to think we might not live to see this earthquake. But now the data is accumulating, and we think this is an earthquake that everybody should be ready for." To understand why, she returns to probabilities. "For any individual, the chance that your house will burn down is pretty small," Jones explains. "It's a lot less than one percent. The chance that you will be affected by this earthquake is a couple of percent." Considered in terms of probabilities, it will seem less like a waste of public funds if we prepare for an earthquake that doesn't happen in the next 50 years. "People need to think more in terms of probabilities," Jones says. "This is part of our public education work. We go through high school thinking that if we're not scientists we don't need statistics. But statistics are key to our understanding of the world."

MANY more mysteries still remain on the southern San Andreas, some of them fundamental questions of physical science that Jones hopes the SoSAFE project will answer. Geologists have yet to determine, for instance, how adjacent faults, such as the San Jacinto, affect the San Andreas. Neither do they know whether ancient earthquakes that started farther north cut into it on their way south, or if some of those earthquakes actually began in the south. Nor can they explain why the fault has not moved in the last 330 years. "Geologists working on the fault refer to it as being 10 months pregnant," Jones says. "But I would argue that it's actually more like being 20 months pregnant, at which point you know you're not dealing with a normal pregnancy. Either the rupture chronology is really irregular or something else is going on."

...one thing's for sure: the last decade's tectonic quiet in Southern California can't last forever.

Two geologists, Glenn Biasi at the University of Nevada and Ray Weldon at the University of Oregon, have devised a probability formula that has been used to estimate that in 1680 an earthquake ripped all the way from the Salton Sea to the Cajon Pass, 100 miles north, and would have registered 7 to 7.5 on the Richter scale, had such a thing been devised back then. "Their formula is based on how much the fault slips at that site," Jones explains. "If you have 25 feet of slip, it's really unlikely that you stopped that earthquake within a short distance; the probability that the rupture would have made it at least 100 miles is pretty high. If you've only got one meter of slip, or a few feet, it's a lot less likely—I mean, it could happen, it could be the beginning of a rupture—but you have a lower probability that two earthquakes some distance from each other joined up."

Over the last three centuries, the southern San Andreas has built up seven meters, or close to 23 feet, of slip. "So that's another one of our questions: If the rupture chronology really is that irregular, do you then release all the slip you've accumulated since the last one?

"Because if you do," Jones warns, "there's no way that earthquake will stay confined to the Coachella Valley. People who believe in that argument—that you've got this big slip, and that slip powers [the earthquake] to keep on going—a lot of those people think that this one is going to go all the way up to Parkfield. And that could be an 8.2."

Whatever the reason for the silence of the southern San Andreas,

and whether it ever slips violently again, one thing's for sure: the last decade's tectonic quiet in Southern California can't last forever. Even if the southern San Andreas stays quiet through the Coachella Valley, there are hundreds, even thousands, more faults that could erupt in the Los Angeles basin.

SINCE 1992, when the Southern California Research Center was founded out of a consortium of universities at the USGS, most of Southern California's complex system of faults, which begins at the Mexican border and extends up to up to San Luis Obispo, has been rigorously mapped; since 2001, GPS technology has made it possible to measure the distance between a network of selected locations over time (Palos Verdes, for example, is moving toward Pasadena at the rate of 4 millimeters per year) and, by detecting abnormal movement in the earth's crust, determine where new faults might be.

But pinpointing the precise locations of those faults, particularly the "blind thrust faults" such as the one that caused the 6.7-magnitude Northridge quake in 1994 and the magnitude 6 Whittier Narrows event in 1987, has been nearly impossible.

"For one thing, we've put people on top of them and paved them all over," Jones says. "If we could have seen them at the surface before, we can't now. For another, even though you can tell that those two points are moving toward one another, the fault that's building up to an earthquake isn't moving—that's the point. Somewhere in between them is a fault that's stuck, and that's where the earthquake will happen. GPS data can't help with that."

BUT there's another process, known as "seismic reflection," that can. Geologists can excavate tunnels, set off explosions and bounce seismic waves off buried rock and record the result, just like an ultrasound or CAT scan in your body. "It's called 'active source exploration,' which is a way of not using the word bombs," Jones says. "Faults reflect seismic waves because the rock has been ground up and changed by rupturing." The explosions occasionally cause surface damage that later has to be repaired, but Jones insists they never set off earthquakes. "There are thousands, millions of these active-source experiments being done, because it's how the oil industry hunts for oil. It's a very well-controlled, well-constrained process." (It was through seismic reflection that the Los Angeles Regional Seismic Experiment, or LARS, was able to locate the Puente Hills thrust, the buried fault system that caused the Whittier Narrows quake.)

JONES recognizes that any kind of earthquake prediction provokes controversy in seismology circles, but she believes there's at least enough data to suggest that earthquakes happen in clusters. "I did some statistical work analyzing the long-term pattern," says Jones, who early in her career spent time studying seismic foreshocks in China, "and looked at the rate of sequences with at least one magnitude 3." About half the region's big earthquakes occurred in periods in which there were 80 to 90 events per year of magnitude 3 or greater. In 2003, there were only 48. After the 7.1 magnitude quake in 1999 near the southern desert town of Hector Mine, the whole network of faults seemed to shut off. In 2006, Jones has observed, the ground got busy again. "We're starting to see a lot of twos and threes," she says. Rumblings have been detected along the San Jacinto fault, and smaller faults are on the move. "At some point we'll be up to the higher rate again," Jones says. "And I think that's probably pretty soon."

"We're calling it the Great Southern California ShakeOut," Jones says. "We're hoping we have a real public earthquake day. Our goal is to get everybody in Southern California to duck, cover, and hold at 10 a.m. on November 13."

It's a good time, then, for Southern Californians to start learning a

few things to help them cope better with the inevitable earthquake, which to Jones mean thinking beyond the proverbial earthquake kit. "Those damn kits!" she laments. "There's a lot you have to do before you can have the luxury of being a surviving victim."

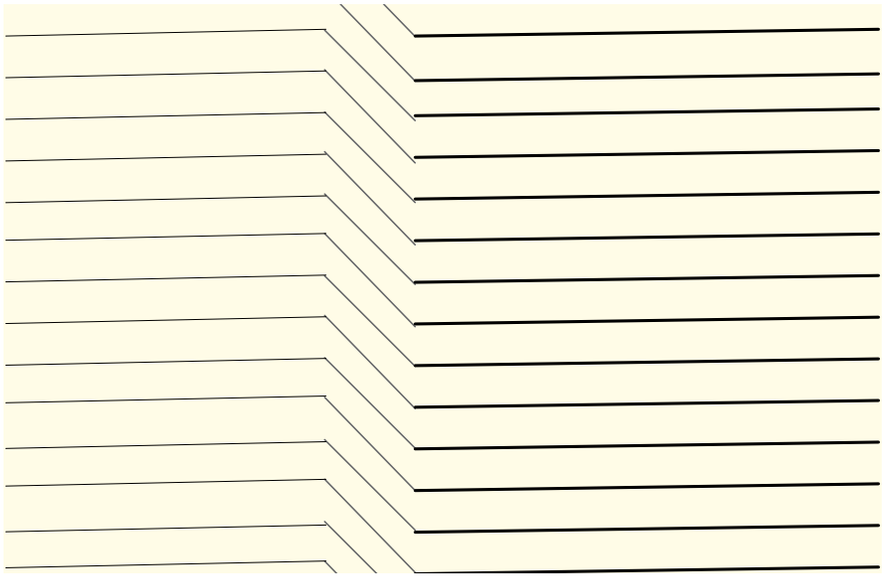
FIRST Jones advises, have the building you live in reinforced if you haven't already done so. Second, "secure your space—the inside of your house. Strap your bookshelves to the wall, and make sure there aren't any heavy pictures hanging over your bed or in your hallway." Then you can think about how much water you have on hand. "Buy ahead on your bottled water," she says, "and make sure that you have food you're actually going to eat." She remembers one elementary school she visited that had stocked 1,000 cans of tuna with no supporting jars of mayonnaise. "What kid in the world will eat dry tuna fish?"

Finally, in order to forestall your own anxiety when the earth starts shaking, learn to count like a geologist.

"WE count to recognize the waves," Jones explains. First comes the "P" wave, a sound wave generated by the vibration of the initial ground rupture. It moves in the same direction that the ground is moving at six kilometers per second. Then comes the slower-moving "S" wave, which vibrates perpendicular to the direction of the fault rupture. By the time delay between the onset of the P wave and the arrival of the S wave, you can estimate your distance from the epicenter.

"Have you ever counted thunder and lightning?" Jones asks. "The time difference between thunder and lightning is five seconds per mile. This is five miles per second. So if you count for three seconds, you're 15 miles from the earthquake."

When the S wave hits—if you can hang on once you've ducked under a heavy object—start counting again. "If you have six seconds of strong shaking, that's a magnitude 6 to 6.5. If you have 25, it's closer to a 7. If it's essentially over in a second, it's a magnitude 5." Unlike the P wave-S wave differential, the duration of the



Ahjung Baik

S wave relative to magnitude doesn't follow a formula. "You have to do it from a table," Jones says, "because it's approximate and very logarithmic."

When Jones visits schools, she teaches children how to count ground motion to help them manage their earthquake panic. "It turns them into scientists instead of scared kids," she says. And she habitually does it herself. When the Landers earthquake hit in 1992, Jones remembers a reporter calling her at home while her bed was still shaking. "He wanted to know what the magnitude was. I told him, 'How do you think I do this? Telepathy?'" Nevertheless, Jones had been counting, and knew the answer.

"I was pretty sure it was a 7 because I had counted for 30 seconds," she says. "It was actually 24 seconds; I had overestimated because I had felt the reverberation." She can't remember

if she gave the reporter the scoop. "I don't think I did," she says. "I didn't want to encourage him."

What will happen to Los Angeles in an 8.2—or, in Jones's more modest scenario, a 7.8—on the southern San Andreas? That's another quandary the multi-hazards project seeks to resolve, by teaming with engineers, economists, and data specialists to model potential outcomes.

"It's sort of the second-order effects of the earthquake that we're interested in," Jones says. "The first-order effect is that when you're near the fault, it's a lot worse. But there are phenomena like the damage Santa Monica suffered during Northridge. Can we model that ahead of time if we understand the basins well enough? Can we understand what happens to the buildings?

"My success depends on getting somone else to do the right thing."

"There's a lot of synergy going on between the research groups right now. There's a lot of excitement, there's a lot of data, a lot of people working on projects that relate to one another. There's a lot more cooperation in the seismology field than we've had at times in the past."

FIFTY to 100 different experts have been assembled to tackle the engineering problems of earthquake preparedness, coordinated by Keith Porter out of Caltech. One group will examine the earthquake's effect on steel-moment buildings, or skyscrapers; CalTrans will use the data to test its transportation infrastructure. Still another program, the National Earthquake Engineers Simulation, or NEES, will examine "non-ductile" reinforced concrete buildings. "Now there's a euphemism for you!" Jones says. "Non-ductile means brittle, but calling a building brittle makes people feel really bad, so we use a different word. But it doesn't change the fact that those buildings kill people." The 7.6 magnitude quake that hit on a long fault near the Turkish city of Izmit in 1999 killed 17,000 people. Most were buried in high-rise apartment buildings made of non-ductile reinforced concrete. In each of the concrete buildings that collapsed, roughly 10 percent of the occupants died.

"WE hope our collapse rate is not as high as it was in Turkey, but when those buildings do collapse, we think that the same casualty rate will apply here," Jones claims. "We need to know where these buildings are."

And once the engineering phase of the project has been completed, Jones says, "we're only halfway done. Then we're working with economists and sociologists and psychologists and public health experts to try and look at the human costs of this. How is this affecting our economic systems? What are the chances of a long-term depression in the L.A. area following the earthquake? What are the casualties, the psychological impacts?" The state's office of emergency services and office of homeland security are both involved, with a promise to conduct an emergency drill on November 13, 2008, based on the multi-hazard project's earthquake model.

"We're calling it the **Great Southern California ShakeOut**," Jones says. "We're hoping we have a real public earthquake day. Our goal is to get everybody in Southern California to duck, cover, and hold at 10 a.m. on November 13; to see if we can get 22 million people to do the earthquake drill." She has high hopes for public education from the project. But whether it all results in making Southern California safer during earthquakes depends on more factors than Jones can control.

"Science can make the community safer. But science alone cannot. I will never be able to do anything to make Southern California safer from earthquakes," she acknowledges. "I can only pull together information that I can explain to a decision-maker who can make us safer.

"Which means I am setting for myself a terribly difficult goal. My success depends on getting someone else to do the right thing."

Kevin Wong

PREPARING L.A. FOR POTENTIAL EARTHQUAKES: APPLICATIONS OF SPACE TECHNOLOGY

Charles Elachi and Andrea Donnellan

THE KEY TO PREDICTING earthquakes, or at least forecasting the probability of earthquakes, is determining where hidden faults lie and how fast those faults are moving.

Charles Elachi is the director of the Jet Propulsion Laboratory and vice president of the California Institute of Technology; **Andrea Donnellan** is the deputy division manager of the Earth and Space Sciences Division at JPL and a research professor at the University of Southern California. Here they tell us how space technology can help discover and diagnose quake-prone rifts in the earth's crust.

TWO hundred billion dollars. That number surely attracts anyone's attention. It equals eight percent of the US federal budget and exceeds the annual budget of every state in the Union. It outstrips the budget of California by over $50 billion.

Two hundred billion dollars in a few seconds. This is the estimated amount of damage that will occur if a magnitude 7 earthquake—the same size quake as hit San Francisco in 1989—were to hit Los Angeles. Southern California is prone to earthquakes and riddled with faults. One quarter of the earthquake risk for the United States lies in Southern California. Since the annualized earthquake losses in the United States are $4.4 billion per year, the economic losses to the Los Angeles area from earthquakes are quite large, and likely to remain so. If the Puente Hills fault, which is located underneath downtown Los Angeles, were to rupture in a magnitude 7.0 earthquake, the economic damage is estimated to be $210 billion and deaths would be expected to exceed 400. By comparison, the magnitude 6.7 Northridge earthquake in 1994 was a $20 billion-plus event that killed over 60 people.

FACED with such staggering consequences and the associated potential loss of life from an L.A. earthquake, as well as resulting fires, disruption, panic, etc., it behooves our advanced society to do whatever we can to be prepared. So one question is, can our scientific and technological advances help us to understand and predict earthquakes, and therefore help in mitigating their effects and be prepared to react effectively whenever and wherever they happen?

Clearly, understanding when and where earthquakes may occur would help mitigate loss of life and property from these damaging events. Recent technological advances in high accuracy global positioning systems and space remote observation and monitoring, associated with scientific modeling have enabled us to significantly improve our understanding of earthquake physics and how the resulting damaging waves propagate. Space-borne technologies, in the form of Global Positioning Systems (GPS) and radar observations are improving our understanding of earthquakes and earthquake processes by precisely measuring deformation of the Earth's surface. The Earth's tectonic plates are continually moving, grinding together and creating enormous stresses where they meet at plate boundaries. This stress accumulation is released in earthquakes. The strain from this accumulation of stress can be measured at the millimeter-per-year level and provide a global view of plate tectonics, earthquakes, and volcanoes.

THE Ring of Fire, a series of plate boundaries where frequent earthquakes and volcanic eruptions occur, encircles the Pacific Ocean. Southern California lies on the boundary between the Pacific and North American plates. Although the plate boundary is quite broad, on the order of 100–200 kilometers, it is marked primarily by the San Andreas Fault, which travels from the south end of the Salton Sea, northward and offshore near Mendocino. North of Los Angeles, the fault changes orientation to a more east/westerly direction. This change in orientation causes north-south compressive stresses creating mountains to the north of Los Angeles and the numerous thrust faults that are found throughout the Los Angeles basin (Figure 1).

In the mid-1990s, scientists started measuring surface motions in the Los Angeles region using GPS. Due to technologies developed at NASA's Jet Propulsion Laboratory, GPS accurately measures the positions of points on the ground anywhere in the world to within just a few millimeters. Using GPS, we have been able to determine that the northern Los Angeles basin is shortening at a rate of about 7 mm per year. The shortening continues to the west, in the Ventura basin, along route 126 between Magic Mountain and Ventura. Prior to the Northridge earthquake we were able to determine that faults on either side of the basin were active, suggesting that the region could produce a

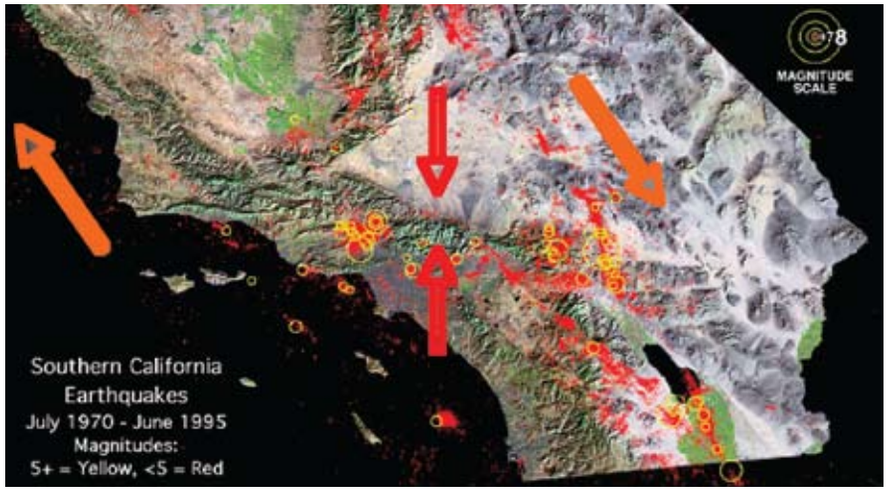


Figure 1. Southern California as seen from space. The orange arrows show the motion of the Pacific and North American plates. The San Andreas Fault can be seen in the relief, starting at the Salton Sea and continuing north of Los Angeles and south of the Mojave Desert. The red arrows show how the stress and motion change in the Los Angeles vicinity.

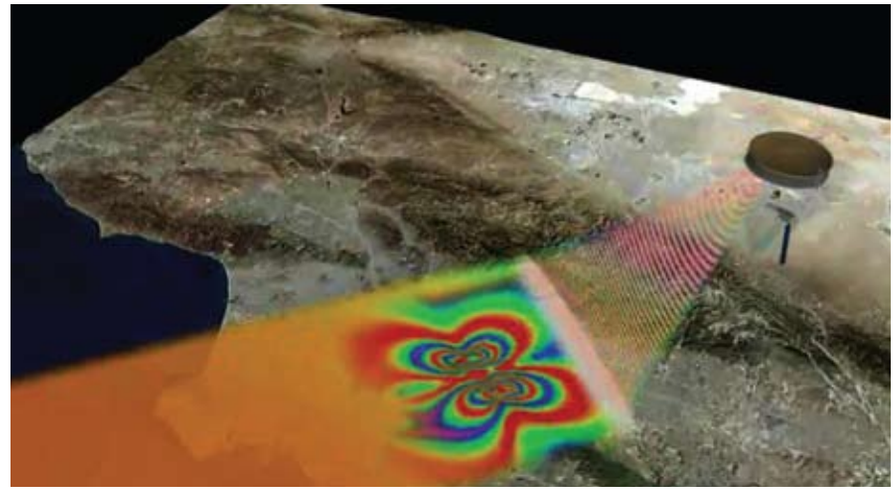


Figure 2. InSAR concept, showing satellite and resulting image were an earthquake to occur near Los Angeles. The fringes are like contours on a map, showing the amount of surface motion towards the satellite.

magnitude 6 or higher earthquake on a thrust fault. The occurrence of the Northridge magnitude 6.7 earthquake was consistent with the GPS observations, showing the value of applying space-borne technologies to earthquake hazard assessment.

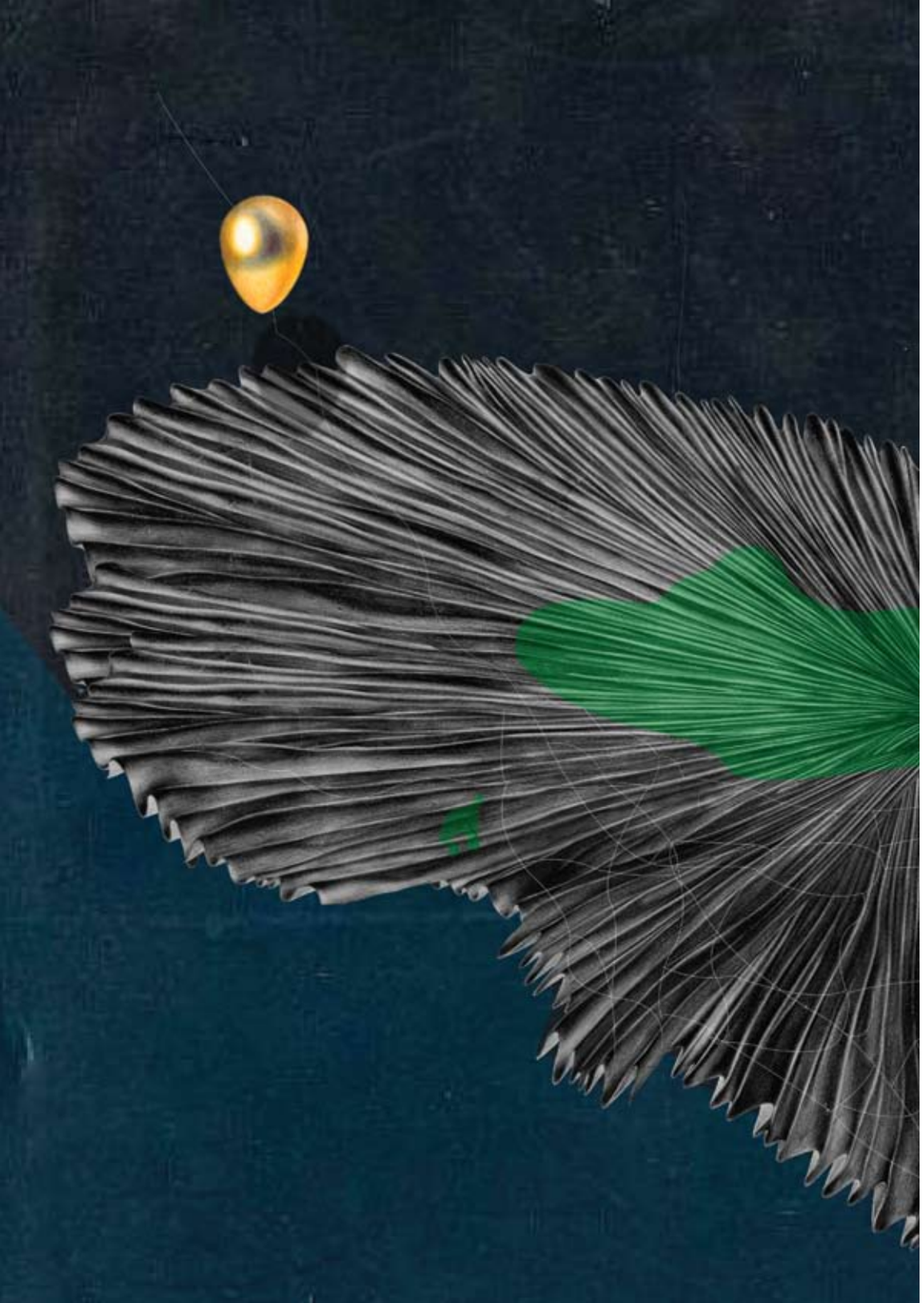
Both GPS and Interferometric Synthetic Aperture Radar (InSAR) were used to measure how the ground moved as a result of the Northridge earthquake. The Santa Susana Mountains, just north of Granada Hills, grew 40 cm during the earthquake. In the two years following the earthquake the mountains continued to grow another 12 cm. Surprisingly, this continued growth was as a result of "afterslip" on the Northridge fault. In essence, the fault broke, slipped during the earthquake, and then continued to slip for more than two years following the earthquake. Ninety percent of the motion after the earthquake was aseismic, or quiet, and could not be measured with seismometers. The earthquake also caused shallow quiet creep on the Sierra Madre fault, which runs the length of the San Gabriel Mountains in the northern L.A. basin. The measurement of surface motions from space-borne technologies are illuminating earthquake processes never before observed. We are now seeing that earthquake faults interact. By using space-borne observations and supercomputers through NASA's QuakeSim project, among others, we can study how one earthquake can either trigger an earthquake on another fault, or reduce the stress such that an otherwise impending earthquake does not occur.

Following the Northridge earthquake, NASA, the National Science Foundation, the U.S. Geological Survey, and the W.M. Keck foundation supported the establishment of the Southern California Integrated GPS Network (SCIGN) as a state of the art dense GPS network for studying surface motions in Southern California. The network is enabling us to see how strain is partitioned across the numerous faults in Los Angeles and Southern California, improving our assessment of earthquake hazards in the region.

InSAR is one of the newest applications for studying earthquakes. Unlike GPS, which precisely measures the motion of a point on the ground, InSAR produces an image of how the entire ground moves (Figure 2). The Landers earthquake was the first earthquake to be observed with InSAR, using the European Radar Satellite-1 (ERS-1). While existing radar satellites are used to produce interferograms, none to date has been optimized for studying earthquakes.

A recent National Academy of Sciences report, "Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond" from the National Research Council (NRC), recommends the launch of a US InSAR satellite called DESDynI (Deformation, Ecosystem Structure, and Dynamics of Ice) in the 2010-2013 time frame. The report represents the consensus of U.S. scientists on critical earth observations from space that are required to address issues for climate change, water resources, ecosystem health, human health, solid-earth natural hazards, and weather. Among other things, the mission would be used to improve forecasts of the likelihood of earthquakes.

Preparing Los Angeles for potential earthquakes requires an improved understanding of how earthquakes occur and how earthquake faults interact. Space-borne technologies, coupled with computer models, will enable us to better understand these processes through measurement and modeling of surface motions, which will ultimately lead to better forecasting of these damaging events. Improved forecasts coupled with an understanding of associated ground shaking and building response, will enable better mitigation strategies—such as targeted retrofitting of buildings—ultimately reducing loss of life and property from major earthquakes in Los Angeles.



Sung-Hae Baik

Excerpt from

THE FOLKLORE OF EARTHQUAKES

Carey McWilliams

AS YOU READ THIS PIECE about the 1933 Long Beach earthquake, you might be struck by how many of the myths that reigned then persist to this day (there was not then, nor is there now, any such thing as "earthquake weather"). A lawyer and historian who for two decades edited *The Nation* magazine, **Carey McWilliams** authored many influential books on the history and landscape of Southern California, including *Southern California: Island on Land*.

ON the basis of their reaction to the word "earthquake," Californians can be divided into three classes: first, the innocent late arrivals who have never felt an earthquake, but who go about avowing to all and sundry that "it must be fun"; next, those who have experienced a slight quake and should know better, but who nonetheless persist in propagating the fable that the San Francisco quake of 1906 was the only major upheaval the state has ever suffered; and last, the victims of a real earthquake—for example, the residents of San Francisco, Santa Barbara, or more recently, Long Beach.* To these last, the world is full of terror. They are supersensitive to the slightest rattles and jars and move uneasily whenever a heavy truck passes along the highway.

This diversity, based on dissimilar experience, is probably responsible for the amazing earthquake folklore that thrives in California. Fresh outpourings of popular fancy appear whenever the region feels another twister. Science is not as sure about earthquakes as it ought to be, and so the Californians make out a fairly plausible case for the superiority of their own lore to the so-called scientific pronouncements elicited by the press from the staffs of the local universities whenever a quake gives another blow to the tourist trade.

THIS popular fancy about earthquakes has crystallized into a trinity of superstitions. They are as follows: that tall buildings in a quake area are peculiarly perilous structures; that quakes are caused by the drainage of oil from the bowels of the earth, and that they are invariably preceded by periods of what is known as "earthquake weather." Los Angeles, under the influence of a widespread belief in the first of these superstitions, adopted an ordinance limiting the heights of buildings years ago. As a consequence of this ordinance (which is also said to have been favored by local realtors animated by ulterior motives), the city has become annoyingly decentralized. In fact, if its tendency to decentralized is not corrected, it will soon become a collection of widely dispersed districts connected by boulevards of racing traffic.

THE belief in earthquake weather is persistent and unshakable. I have heard old residents quarrel endlessly among themselves over the exact definition of it, but they all agree that it exists and that it invariably presages the coming of a quake. Despite the fact that it is common knowledge that earthquakes have occurred in summer and in winter, in spring and fall, and every hour of the day or night, regardless of temperature, the belief in this earthquake weather survives. In the popular sense, the phrase seems to designate a close, stifling, sunless, muggy atmosphere. One might be ready to believe that such weather does presage the coming of quakes if it were not for the at that the description obviously refers to an atmospheric condition that, in California, is the subject of universal detestation. The conclusion is almost irresistible that the residents have merely made the loathsome "close days" responsible for calamities that could not, in loyalty, be imputed to any other kind of weather.

The belief in the oil-drainage superstition is of equal antiquity and tenacity. There is, as a matter of fact, a slightly melodramatic quality about oil fields. The great shining storage tanks glisten in the sun; the forest of derricks assume fantastic shapes in mist and cloud, light and darkness; and the ceaseless thumping of the pumps makes for an atmosphere of doubt and misgiving. Oil drillers themselves are a notoriously superstitious breed of men.

BUT the range of popular fancy is not limited to any particular set of superstitions. After the recent temblor that caused such heavy damage at Long Beach and the surrounding towns, I was able to cull the following yarns from the local press and from conversations overheard during the next few days. It seems that a hen laid three eggs a few moments after the first shock was felt; that a woman who

had been suffering from paralysis for years was cured by the vibrations of the quake and walked forth from an invalid's room without assistance; that the quake was predicted by the "scientists" weeks before it occurred, but that the information was suppressed by certain sinister interests variously known as the big me, the bankers, and the university presidents; that a woman was taking a bath in Long Beach when the first shock came, causing a section of the wall to fall in and block the doorway, so that she was forced to remain in the bathroom without clothes for three days and nights until she was rescued by some Legionnaire; that sixteen boys were caught in the plunge of the Polytechnic High School in Long Beach, but that they have never been reported missing, and that their parents have been hushed up; that while standing in a neighboring building gazing out at the new Los Angeles City Hall (twenty floors and a tower), a group of people saw the hall sway out of sight, come back into sight, sway out of sight in the opposite direction and then come to rest "with an awful jar"; that a worker in a chemical plant near Long Beach was thrown thirty feet in the air after the first shock, and that, on hitting the ground, he bounced skyward and was thus tossed up and down three times "in rapid succession": that the earthquake was caused by the moving mountain near Durango, Colorado; that an automobile, while being driven along a boulevard in Long Beach, shook so hard that it lost all four tires; that the undertakers in Long Beach didn't charge a penny for the sixty or more interments following the quake; that the quake was the first manifestation of the awful curse placed on Southern California by the Rev. Robert P. Shuler after its residents failed to elect him United States Senator; that sailors on vessels a mile or more off shore from Palos Verdes saw the hills (quite high) disappear from sight; that the bootleggers of Long Beach saved hundreds of lives by their public-spirited donation of large quantities of alcohol to the medical authorities; that women showed the most courage during the quake and that men can't stand up under earthquakes; that the shock of the quake caused dozens of miscarriages in Long Beach, and that an earthquake will often cause permanent, and annoying, irregularities among women; that every building in Southern California that was not damaged by the quake is "earthquake proof"; that another earthquake will be experienced within three months "at the other end of the fault"; that a cross on a Long Beach church was not damaged, though the rest of the building was destroyed; that the quake will disturb the production of oil by causing it to flow from one underground reservoir to another; that every life lost during the quake was due solely to the obdurate willfulness of the dead in not doing what the speaker would have brilliantly done under the same circumstances; that an earthquake is much more terrifying than a cyclone, but not quite as terrifying as a tornado, and just slightly less ghastly than a hurricane; that Californians should construct earthquake cellars, just as Middle Westerners build cyclone cellars; that the "first quake is always the hardest," and that, in reality, there is only one quake, the subsequent temblors being regarded as merely "echoes" or "repercussions" of the first; that the safest place to be when an earthquake occurs is indoors, outdoors, in a doorway, standing next to an interior partition, lying relaxed on the floor; that the outdoor camping and enforced communalization of life after the quake in Long Beach produced widespread immorality; that it is extremely dangerous to rush out of doors during an earthquake, for the reason that "great cracks" are likely to occur in the paving, or one may be struck by a runaway vehicle; that the last quake occurred in California in Santa Barbara in 1926, and the first in San Francisco in 1906, and that, between these dates, California did not experience an earthquake; that every community in Southern California which escaped serious damage in the last quake "is not in the path of the fault," and is, therefore, immune from peril; that the earthquake, followed by the appearance of a mighty meteor on March 24, presages the beginning of the end. ♂

SECTION 2:
BUILDING FOR THE BIG ONE

[A]S I REELED about on the pavement trying to keep my footing, I saw a sight! The entire front of a tall four-story brick building in Third street sprung outward like a door and fell sprawling across the street, raising a dust like a great volume of smoke!

—Mark Twain, *Roughing It* (1872)

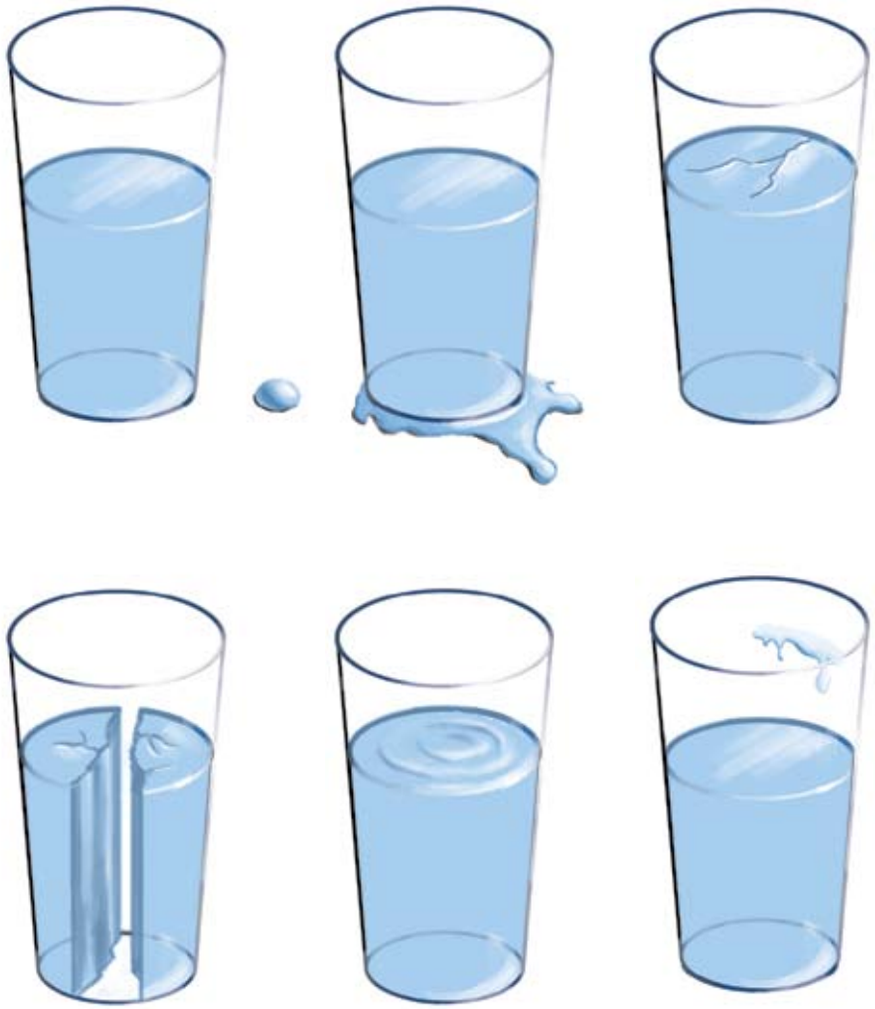
IN 1968, a scientist by the name of Nick Ambraseys, at 39 already a preeminent world authority on earthquakes, seaquakes and tsunamis, gave a lecture at Cambridge University that, according to geologist and author Roger Bilham, would forever change the way the world thought about earthquakes. "In 50 short minutes," Bilham has written, "[Ambraseys] demonstrated links between engineering and history, earthquakes and civilization, and scientists and society." His most famous take-away quote from that lecture was one Bilham would again invoke 20 years later, after a deadly quake killed tens of thousands in Armenia. "Earthquakes don't kill people," Ambraseys said. "Buildings do."

That widely circulated quote might sound almost axiomatic by now, so obvious it is that no one dies in an earthquake who isn't under something that falls. And still, all around the world, when significant earthquakes roll through large, modern cities, people continue to be crushed in the debris of falling buildings. The magnitude 7.9 earthquake that devastated Sichuan Province, China on May 12, 2008, is only the most recent, heartrending example: After 100 seconds of strong shaking, more than 7,000 classrooms collapsed during the middle of the school day, killing tens of thousands of children. In many areas where the schools came down, more sturdily constructed buildings remained standing.

California has strict life-safety provision written into its building codes that have saved lives for three-quarters of a century, holding death tolls from modern quakes firmly in the double digits. (The 1989 Loma Prieta earthquake near San Francisco, claimed 67 lives; that same year, more than 10,000 died in an earthquake of the same force near Mexico City.) Public schools in California do even better, thanks to a 1933 law that governs their construction, which is discussed in the following pages.

BUT geological time is long, and Los Angeles by its standards has been around for less than a flash of light in a thousand years of sun. We have not yet had an earthquake to match the one on the Longmenshan Fault in Sichuan Province, although, as mentioned elsewhere in this book, we can expect one. Many structural engineers and geologists worry that older brick buildings, as well as some aging commercial and industrial concrete buildings, could collapse in a period of prolonged, intense shaking. Even some high-rise buildings —otherwise known as "steel moment-frame" buildings—may tumble.

IN the following section, engineers, architects, and others weigh in on what it means to build, and then live without worry, in a zone of seismic activity. Susan Tubbesing, executive director of the Earthquake Engineering Research Institute, in a conversation with Aileen Farnan Antonier in this next section, describes what engineers learned about building after Northridge; Caltech President Jean-Lou Chameau and former Provost Paul Jennings discuss how engineers and seismologists, in the tradition of Abramseys, have been collaborating to predict how a certain types of construction will respond to an extended period of strong shaking; and architect Thom Mayne celebrates the inherent beauty of a wood-frame house—a structure "so elastic," he says, "that everything can roll down one side, yet they don't collapse." Just don't build one on the edge of a cliff.



Eric Lin

Excerpt from

ANNALS OF THE FORMER WORLD

John McPhee

THIS SCENE from **John McPhee's** Pulitzer Prize-winning book, *Annals of the Former World* (1999), was originally the final story in *Assembling California* (1992), the chronicle of a 15-year-long geological tour McPhee took in the company of geologist Eldrige Moores. It takes place at Mussel Rock, a towering slab of Mesozoic-age greenstone shoved up by subducting plates at the point where the San Andreas Fault meets the sea. "It's a good place," McPhee observed, "to sit and watch the plates move." And to marvel at the nonchalance of those who build their homes at fault's edge.

AN Earthquake.

A small flex of mobility in a planetary shell so mobile that nothing on it resembles itself as it was some years before, when nothing on it resembled itself as it was some years before that, when nothing on it...

Not long ago, at Mussel Rock, a man named Araullo was fishing. He had a long pole that looked European. He seemed not so much to be casting his lure as sweeping it through the sea. His home was near the top of the cliff. He pointed proudly. The one nearest the view.

He had come down the trail and jumped over water to a wide, flat boulder. The seismic crack that came down the cliff ran into the water and under the boulder. He was fishing the San Andreas Fault, and he was having no luck.

I asked him, "What are you after?"

He said, "Sea perch. I also get salmon and striped bass here. Now I don't know where they are. Someday, they come."

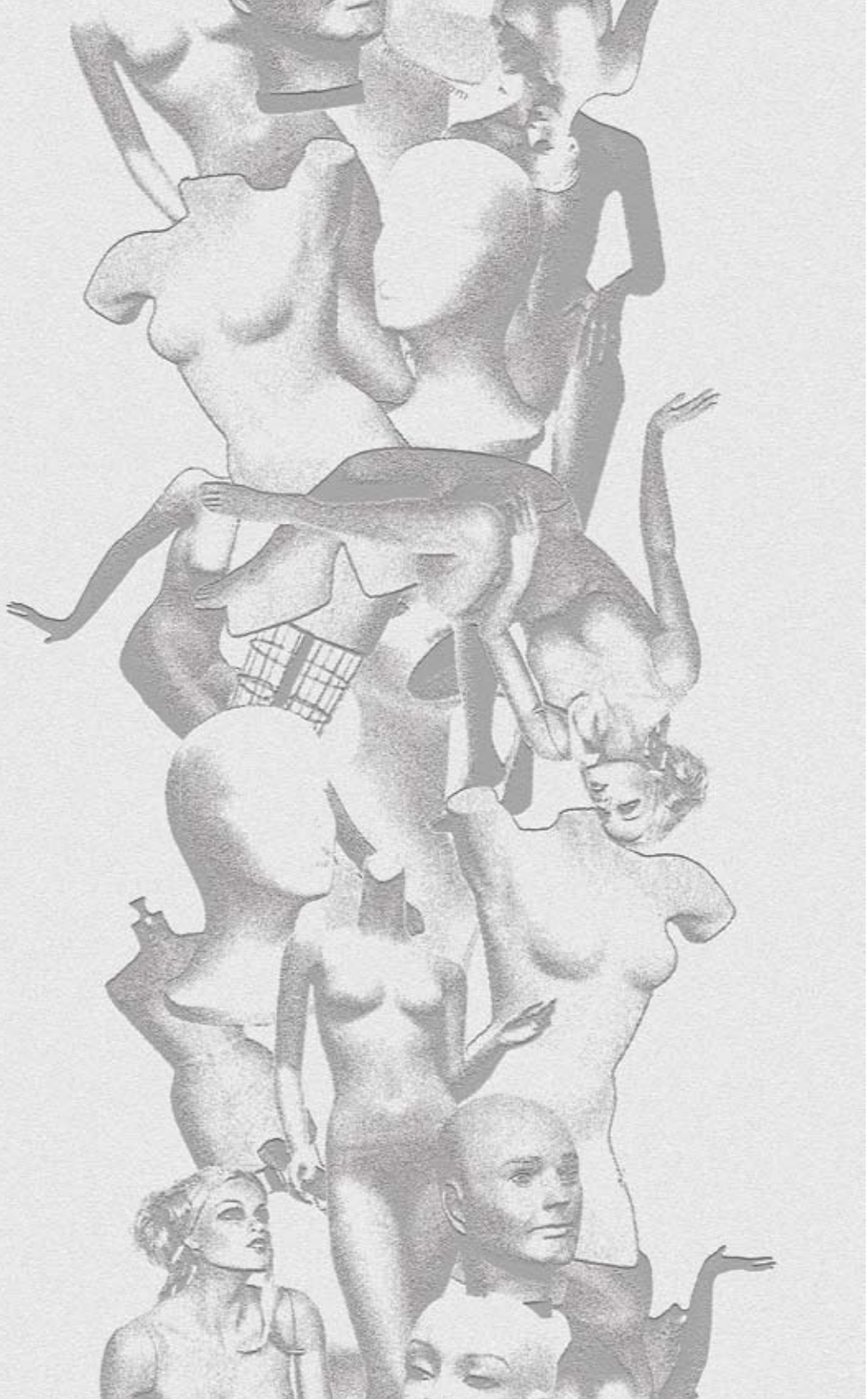
He said that he felt very fortunate to have a house so close to the fish and ocean, to have been able to afford it. He had bought it six months before. In this particular location, real estate was cheap. He had bought the house for a hundred and seventy thousand. I could barely hear him over the sound of the waves.

"If it going to go down, it going to go down," he shouted, and he flailed the green sea. "You never know what going to happen. Only God knows. Hey, we got the whole view of the ocean. We go the Mussel Rock. What else we need for? This is life. If it go down, we go down with it."

THE cormorants were present, and the pelicans. The big fishing boulder echeloned with shears. From somewhere near Araullo's house, a hang glider had left the jumpy earth and now hovered safely above us.

Araullo ignored the hang glider and kept on swinging his pole.

"I don't know where they are," he said again. "But someday they come. They always come."



Hsing Ling Tsai

EARTHQUAKES ARE FABULOUS

An interview with Thom Mayne by Dana Hutt

PRITZKER PRIZE-WINNING architect **Thom Mayne** is the founder of the Los Angeles-based firm Morphosis. His most recent buildings include the acclaimed CalTrans District Seven Headquarters in downtown Los Angeles and the United States Office Building in San Francisco. He also designed the 68-story Phare Tower, which, when completed in 2012, will be the tallest building to be constructed in Paris since the Eiffel Tower in 1889. Mayne told Dana Hutt, director of Architectural Documentation and Special Projects at Art Center College of Design, about his thoughts on the relationship of earthquakes and the built environment.

In Los Angeles, you approach the work knowing that it will by necessity have structural redundancy that will produce a different kind of sensibility.

Earthquakes don't disturb me

Everybody has different thresholds for things that frighten or disturb them, and this is an area that I'm somehow very relaxed about. In 1971, when the San Fernando quake hit, I was living in Venice, above the bait and tackle shop at the end of the pier. The building rocked around, bookshelves tipped over, and everything ended up on the floor. It was in the morning hours, and after looking around and surveying the mess, I climbed into bed and went back to sleep. I woke up two or three hours later, turned on the news, went to have a coffee down the street, and came back and spent the next couple of days cleaning up my house. Then, in 1994, I was living in Ocean Park, about a mile from my old place but in a really stable little house built with sheeted plywood, and there was a bit of rattling in the morning. I got up, turned on the television and watched what was unfolding. Northridge was very severe, with collapses and fires as close to me as Santa Monica. But, still, I kind of shrugged.

Earthquakes change the work of architects

Earthquakes have hugely affected what we do. When you also work nationally and internationally, you become acutely aware that because of the seismic threat everything in Los Angeles gets thicker, bigger, and kind of clumsier. We're working in Paris right now, on the Phare Tower, which is really light and delicate, something that is possible only because it's a zero seismic zone. The same was true in Austria, years ago, when we worked on the Hypo Bank. Location has to be a critical element in an architect's thinking.

In Southern California, you come to realize that one of the continuities of work is going to be a heaviness, and as seismic safety laws are constantly being updated and strengthened, that's a trend that is not going to reverse. In Los Angeles, you approach the work knowing that it will by necessity have structural redundancy that will produce a different kind of sensibility. It does in fact change the work because you completely rule out certain options as to how a building touches the ground. Our federal office building in San Francisco is a concrete building,but it's thin, so it was a very complicated building to make work within a high seismic zone. It had just a ridiculous amount of steel and became hugely heavy.

Although you're not working based directly on the idea of the earthquake, you do have to work within certain parameters and learn to deal with things quite differently. And it starts with structure. As an architect, seismic concerns infiltrate once you realize it's not the vertical, but the horizontal force—the lateral load—that's of utmost importance, and that really changes your thinking.

The more knowledge you have gives you a different way of deciding how you're going to build. Building in Los Angeles is also an economic issue because dealing with these situations is expensive. It has to do with how we understand nature and our relationship with nature; it is part of a contextualism. Of course this city is complicated because it has multiple ecologies, each with its own specific requirements: the low coastline, the edge of a sea cliff, mountain ridges and valleys, the desert, downtown. These conditions are all different, and we have a choice of how to respond to those conditions.

Earthquakes don't defeat the wood-frame house (usually)

If you're in a little wood-frame house, there's often not much to worry about beyond checking the gas connection to ensure that it's flexible. In an older house that sits on an old-fashioned foundation, which might not be made with the strongest materials, you should probably upgrade the foundation. But what is so lovely about a

wood-frame house is its incredible redundancy, with thousands of little connections made by nails, versus a big building that can have a single-system failure, or even the failure of a system and a backup system. These houses, even the ones built in the 1920s and '30s, are so elastic that everything can roll down one side, yet they don't collapse. Again, the main danger is that when they tip, the gas connection can break. Beyond that, the integrity of the home's site is often the biggest problem in L.A., with its mountains and edges of water. There's going to be a lot of movement of earth, and that's where you're going to find problems that are unsolvable.

Earthquakes are part of a natural cycle

For me, earthquakes are in tune with my knowledge of nature. Earthquakes make total sense; they are supposed to happen, and they're supposed to happen here. If you're sailing, you accept huge potential dangers because you're aware of the environment, of

If you buy a house on the edge of a cliff along the coast in Pacific Palisades, how can it be startling when the cliff gives way and suddenly you have no property?

the unrestrainable power of the sea, which is part of the natural condition. In Los Angeles, earthquakes—like the fires that regularly occur during our fire "season"—are actually a normal occurrence. It's part of living in L.A. I am constantly perplexed as to why so many people who live here don't even consider the impact an earthquake could and will have on them. It's intriguing that earthquakes are something that you learn to live with—like all relationships between human beings and nature.

Somehow, earthquake-preparedness is hard to keep attentive to; it's like a seat belt. You might never use a seat belt in your whole life – in fact most people will never use a seat belt – but you put it on everyday, knowing that it only has to be used once to save your life. And earthquake-preparedness is this issue at a huge macro level: To keep people actively aware a whole lifetime, where they may never once activate their knowledge or their expertise. On a psychological level I find that really interesting. If you buy a house on the edge of a cliff along the coast in Pacific Palisades, how can it be startling when the cliff gives way and suddenly you have no property, and perhaps find yourself in physical danger? But that's the nature of buying that type of property.

Earthquakes are fabulous

Iceland has active volcanoes and is literally on two, moving tectonic plates.* [The ridge between them is] like the San Andreas Fault. Part of it is quite wide, and you can see down a crevice. It's wild. You're literally looking at the earth as it's moving, and as it has moved over millions of years. Then you go around the island, and there's a spewing volcano and natural hot springs, and you feel like you're there at the creation of the universe or you're somehow witnessing the making of this planet. It's like Italo Calvino's "Cosmicomics."

Emotionally, I love an earthquake and the fact that it's instantaneous. An earthquake causes this huge wave, like a land tsunami that hits your house. I remember the one in Venice: there was a bam! Just one solid hit and everything collapses. And then after that there was all this sound. It's like jazz—hugely energizing and invigorating. Fabulous.

** Iceland straddles the Mid-Atlantic Ridge, which is the boundary between the North American and Eurasian plates.*

Clifford Elbl

ENGINEERING FROM END TO END: A NEW APPROACH TO MODELING SEISMIC ACTIVITY

An interview with
Jean-Lou Chameau & Paul Jennings
by Judith Lewis

THE FORMER DEAN of the Georgia Tech College of Engineering, **Jean-Lou Chameau's** technical interests include sustainable technology, environmental geotechnology, soil dynamics, earthquake engineering, and liquefaction of soils. Chameau received his secondary and undergraduate education in France; in 1980, after completing his graduate work at Stanford University, he joined the civil engineering faculty at Purdue University, where he subsequently became full

professor and head of the geotechnical engineering program. In September 2006, he became Caltech's eighth president.

INTERNATIONALLY RENOWNED earthquake engineering and seismology expert **Paul Jennings** has been on the California Institute of Technology campus as a student, professor, and administrator for 44 years. From 1989 to 1995, he was both Vice President and Provost; in 2004, he returned as Provost after a nine-year hiatus, and remained in that position through 2007.

THE TWO MEN spoke with Judith Lewis about the latest research in understanding seismic zones and how to engineer safe construction within them.

As leaders of a large institution in an earthquake-prone city, what advances in research at Caltech today are most significant in terms of the public's understanding of earthquakes?

J: (Paul Jennings) One of the things that demonstrates the breadth of what we can do is called end-to-end modeling. The engineers and seismologists are working together and taking a big earthquake on the San Andreas Fault as an example, and they're now modeling the process from end to end. That's one of the significant advances in the research.

C: (Jean-Lou Chameau) I remember being a graduate student 30 years ago and we were discussing this idea on the blackboard. Professors were showing the concept, and we had to make assumptions to develop code models to do it. So the concept has been in place for a long time, but it's only the computational tools—including the two- and three-dimensional graphics—of the last few years that have made it possible to actually put it into practice.

What exactly does "end-to-end" mean?

J: It means you can simulate both the beginning and the end of the earthquake scenario. You can model the source—where the energy is actually released by a sudden movement along the fault—and you can propagate the seismic waves of the earthquake through all the different kinds of geology in the L.A. basin. There's a big basin of sediment out here 30,000 feet deep, and in Los Angeles we've also got mountains and ridges. All of those geological features affect the modeling.

What do you learn from end-to-end modeling?

J: Using a geometric visual image of the fault, you can calculate the ground shaking at a large number of points on the surface of the ground in the Southern California region. In part of that calculation, you put a model of a building at any one of those points, and you can determine how a building of that type would respond if it were in that location during a big earthquake on the San Andreas Fault. You can do this for different scenarios of the earthquake; where the earthquake starts up north and propagates toward the south, for example, which is bad for us in Los Angeles, or if it starts at the south end and goes up toward the northwest, which is good for Los Angeles. There's a Doppler effect to seismic energy: the energy gets focused in the direction of rupture. So if the rupture's coming toward you, you get stronger shaking than if the rupture's going away from you.

Then you can apply those different scenarios to different types of buildings. You can have a modern 20-story steel-frame building designed according to the latest standards, and then you can also ask, "How would a building built 20 years ago respond at the same site?"

Is there any way of determining whether a rupture will come toward us from the north or the southwest?

J: No. It could also start in the middle and go both ways. All of these things have happened. If you have a big earthquake, a seismologist can tell you afterward where the main source of energy started and which direction it ruptured, but to predict it beforehand seems beyond anybody's capability.

What are your expectations for how this information will be used, and how people will react to it?

C: The end-to-end work, which we couldn't do 10 or 15 years ago, provides an important new tool for architects and engineers. They can now see what would happen to a particular structure, and design a building slightly differently in one part of town, say, than in another, taking into account uncertainties, local differences in loading, materials, and structure conditions.

J: End-to-end modeling also helps you quantify the uncertainties a little. There are uncertainties about the performance of a building and its material properties. There are uncertainties about the propagation calculation—how waves move—and there's uncertainty about what actually happens in the earthquake itself. Where are the sources of energy release and which way does it go?

It turns out that it's helpful for the public and the specialists, too, to ask, "Where are the big unknowns here? And can we do anything about them?" By addressing these questions, we hope to influence decisions.

In what area of seismologic research is there the most uncertainty?

J: The largest unknowns are in the geologic process itself: how big an earthquake is and where it is and which way it propagates. That's a very big unknown. The unknowns with the building are sizable but they're not nearly as large as the uncertainties in the geological part of the equation. That complicates life because a big earthquake could come and nothing much might happen, and the reason could be that we were just very lucky on the geology. And the next one may not be as big, but everything else goes wrong.

A big earthquake could come and nothing much might happen, and the reason could be that we were just very lucky on the geology. And the next one may not be as big, but everything else goes wrong.

That's not nice news in some sense, but it certainly helps with a more realistic understanding and more realistic policies, because with end-to-end modeling, you're looking at the whole picture, from the earthquake to the response of the building. It frames the consequences in a way that people can grasp. Maybe they can't understand the exact calculations, but visually, you can make a movie that shows the fault moving, the ground shaking and the building shaking. You can put things together in a way that people feel they can address the problem.

How do you know that the results your calculations and modeling predict accurately represent what will happen in the real world?

J: We've been refining these processes over the past 15 to 20 years, and actually have the measurements from past events. If an earthquake occurs now, we can make a rough calculation of the strength of the shaking in an affected region even before we get the instrumental measurements.

Also, there have been enough advances in instrumentation that you can calibrate these things. When you have a sizable earthquake today, it's recorded on hundreds of seismometers. From those, you can go back and get some details of how the source actually generated the energy. A

fault may rupture for 50 miles, but the energy's not distributed evenly along it. It's very uneven in fact. But you can look at the calculations and get some idea of where the energy was released.

Once you've gone back and done that, then you can do the forward calculation and say, okay, now, let the energy be released the same way on this computer, and then let's go out and calculate the motion in every place you had a seismogram and compare the calculated value with the observed value.

This calibrates the modeling of the geologic structure. If you do that enough times, you get pretty good at modeling and have confidence in your calculations.

C: One thing to remember, though, is that although we have quite a bit of information from small and moderate size earthquakes, we have much less information available from very large ones. They don't happen very often, and they rarely happen in areas where you have the most instrumentation and the most concern about potential damage.

Since those big earthquakes are so infrequent, how do you capture people's attention and reinvigorate this topic when there's nothing happening seismically?

C: It's human nature to lose interest. No one moves to act without actually experiencing the risk. If you look at the history of the building codes, basically they changed every time there was a significant earthquake that revealed problems we didn't anticipate well before. There is an earthquake, and there are commissions and committees that start to look at the research that was done before, and they change the code. And nothing significant then happens until the next earthquake.

J: This goes back to the 1872 earthquake, which led to the banning of adobe construction, because a lot of people were killed in unreinforced adobe buildings. Fortunately, we now have very few adobe homes in Southern California because of that event and what people learned from it. In terms of keeping people interested, one of the things that does help is that there's better worldwide communication, so when earthquakes happen in other parts of the world people are reminded what can happen if you're not prepared for it.

You mentioned that end-to-end modeling took some 30 years to go from concept to practice. What do you expect to be the next leap forward in the decades ahead?

C: I think that we will start to better understand how the earthquake is actually rupturing at its source—how it is actually occurring—as well as a better simulation of how it propagates. And that will remove a major part of the geological uncertainty of the event.

J: If you could find out how the stress is building up on the fault, in enough detail to be useful, that would dramatically reduce the uncertainty in the calculations, because you'd know where the energy release is coming from.

On the structural engineering side, the buildings we're using now are important buildings, like steel-frame buildings, but they're not geometrically complex. They're not odd shapes. We haven't modeled any state-of-the-art architecture. As an incremental advance, we'd like to extend what we're doing to a wider class of realistic buildings.

Is there a cycle of seismic activity that will help us anticipate large earthquakes?

J: We wish we knew. We've had all kinds of patterns in the past. We've had gaps for significant periods of time where nothing much happens. We've had clusters of earthquakes where a lot happens over time. Sometimes for a particular big earthquake you have a

foreshock series that keeps increasing. One Chinese earthquake was "predicted" on the basis of foreshock activity.

But sometimes a big one just comes out of the blue. And one of the things Lucy Jones studies in her research is whether there's something in the pre-earthquake sequence that gives you some idea of what's happening. It's not obvious whether there is.

C: There was a lot of optimism about forecasting earthquakes in the late '70s and '80s—and in fact the Chinese earthquake in 1975 [7.3 magnitude near Haicheng-Yingkow] was an example cited by some. There were a lot of people looking at clusters, and we were maybe thinking you could predict it based on some of those observations. But since then there have been a number of cases that didn't match any of those things. I'm seeing less excitement about predications. Instead, people are focusing more efforts on forecasting the potential effects of the earthquake, through things like the end-to-end modeling.

J: It's a very interesting problem because it's a tremendously large event, and it releases huge amounts of energy, and it's quite reasonable to think such an event would have some precursors. If you take anything in the lab—rock, concrete, steel, or anything—and try to break it, something happens before it breaks. And you can measure it. Most things that are much simpler have precursors. Why does this huge event, releasing megatons of energy, not have a precursor?

This is a very good scientific question. Is it a buildup of strain that you can observe on the surface of the ground? That's one hypothesis. Is it a change in the electromagnetic field around the fault? Is that a hypothesis? Looking at foreshock activity seems very sensible; if you try to break a stick, it cracks first and then it breaks. Why not look for that? But, so far, nothing has proved very reliable.

If you're going to study earthquake prediction, that's a fundamental thing. But if you don't know what to measure and where to measure it, that's a problem.

C: Technically, scientifically, it makes sense to expect precursor activity of some sort. It seems that we have not really discovered yet what it is or what could be monitored with a high level of repeatability and reliability. We have observed a number of different things, but they don't seem to repeat themselves on a consistent basis.

J: It may be there are many different kinds of earthquakes, like there are many different kinds of cancers. People think it's one simple disease, but it's not. It's very complicated. Maybe there's something scientifically similar going on with earthquakes. We know there are different kinds of earthquakes, but maybe some are really fundamentally different in some way we haven't detected yet.

There are so many branches to earthquake research. How do you decide where to prioritize your resources?

J: At Caltech, we don't set our priorities from the top down. What happens here is that when we look for new faculty—as recently, when we hired a new seismologist and a new earthquake engineer—we look for the best possible person in some reasonably broad field. We choose the very best minds, and let our faculty lead the way. They are always asking themselves where we should go next. What's the most important problem to work on? This shapes our future direction.

What is your own personal response to living here in earthquake country?

C: Look outside! This is a great and dynamic environment. The weather is beautiful. It's worth the risk! Nevertheless, all of us should be prepared for the possibility of an earthquake. Preparation applies to both individuals and organizations such as Caltech.

Anthony Van Groningen

A COMPREHENSIVE APPROACH TO EARTHQUAKE ENGINEERING: LESSONS FROM NORTHRIDGE AND BEYOND

An interview with Susan Tubbesing by Aileen Farnan Antonier

IN 2000, the Earthquake Engineering Research Institute (EERI) assembled a panel of leading scientists and engineers and, with financial support from the National Science Foundation, began a comprehensive investigation in reducing life and property loss from earthquakes. The completed report, "Security Society Against

Catastrophic Earthquake Losses," was published in 2003, and offers "a new comprehensive vision from the earthquake engineering community for the rapid development and deployment of leading-edge research to create safer, more resilient communities." EERI's involvement has been instrumental in securing the reauthorization of funding critical research in both the applied and social sciences. Here, **Susan K. Tubbesing,** executive director of the Oakland, California, based institute, talks to Aileen Farnan Antonier about EERI's work, the motives behind the 2003 study, and what engineers learned about high-rises after Northridge.

What is EERI's role in the event of an earthquake?

After an earthquake, we gather information that can be used to improve our assessment of earthquake hazards, and to document the effects of earthquakes on the built environment and the resulting social, economic, and policy impacts. This information helps us improve structures, mitigation strategies, and emergency response procedures. Prior to the 1994 Northridge earthquake, we would send a small, self-contained group of about eight to 10 people to the site of the event. Each person was responsible for a particular area, whether it was earth sciences, structural performance, urban planning, or societal impact. For example, a seismologist would deploy instruments that measured aftershocks, and a geologist would document ground failures. A structural engineer would evaluate the effects of the earthquake on the built environment, while a social scientist would study the event's effects on people and businesses. The information we collect is very perishable, so it is important that it's done quickly.

Because the Northridge quake produced more data than ever before, we created a new team structure to study the event. Instead of just one person in each discipline, there were team leaders who managed sub-teams that reported back with the information they gathered. There were literally hundreds of people who contributed their observations to that effort.

As it happened, the California Office of Emergency Services had a regional office in Pasadena, which couldn't have been more convenient to survey the damage in Northridge. They gave us a floor of that facility, where we set up a post-earthquake technical clearinghouse operation, a place for engineers and scientists to report their findings each day.

That was the model we used in establishing our current plan for a California information clearinghouse after an earthquake. Fortunately we haven't been tested yet.

What were the most important findings to come out of the Northridge analysis?

The engineering community certainly was shocked to discover that welded steel moment-frame structures, which they thought were really very safe and very resilient, sustained many cracks in the welds. That discovery generated an $8 million research study that was funded by FEMA and involved the Structural Engineers Association of California, the Applied Technology Council, and the Consortium of Universities for Research in Earthquake Engineering. Those three organizations worked together and carried out tests at universities on the welds of materials. They came up with new materials and new specifications for the weld materials and for the steel itself, for how it should be fabricated, and for how it should then be applied. Until the analysis was complete and before new guidelines were developed, it put a lot of major projects on hold in Los Angeles. Some engineers switched materials and went to a design using concrete and other approaches.

How did EERI's 2003 report come about?

Our board of directors felt it was important to get a sense of how much it would cost to really make a difference in reducing earthquake losses, so they identified people who were leaders in each of their fields—earth sciences, earthquake engineering, and the

social sciences. They looked at the new developments that were on the horizon in their fields and estimated how much research it would take and the kinds of implementation that would be required. It was a major effort that took about a year and a half.

In the end, the report determined that in order to reduce the acceleration of earthquake risk and potential losses, it would take approximately $350 million a year over a period of 20 years to begin to get a handle on the escalating losses. That's about three times as much money as Congress is currently putting into the National Earthquake Hazard Reduction Program (NEHRP), because the funding level has not changed much from what it was—$100 million—in 1978.

We then secured the endorsement of more than 30 other organizations in support of the conclusions, took the document to Congress, and introduced it to the Science Committee of the House of Representatives. Ultimately, the report helped to increase the congressional authorization levels for NEHRP, but unfortunately the actual appropriation has not gone up very much.

What kind of impact has the report had elsewhere?

The biggest outcome has been the continued funding of NEES, which stands for the Network for Earthquake Engineering Simulation, a distributed system of earthquake testing facilities throughout the country. Fifteen experimental testing facilities are linked and able to remotely share tools, data, and simulation software for earthquake engineering testing. NEES enables researchers to collaborate on developing better and more cost-effective ways of mitigating earthquake damage, using experimental and computational simulation.

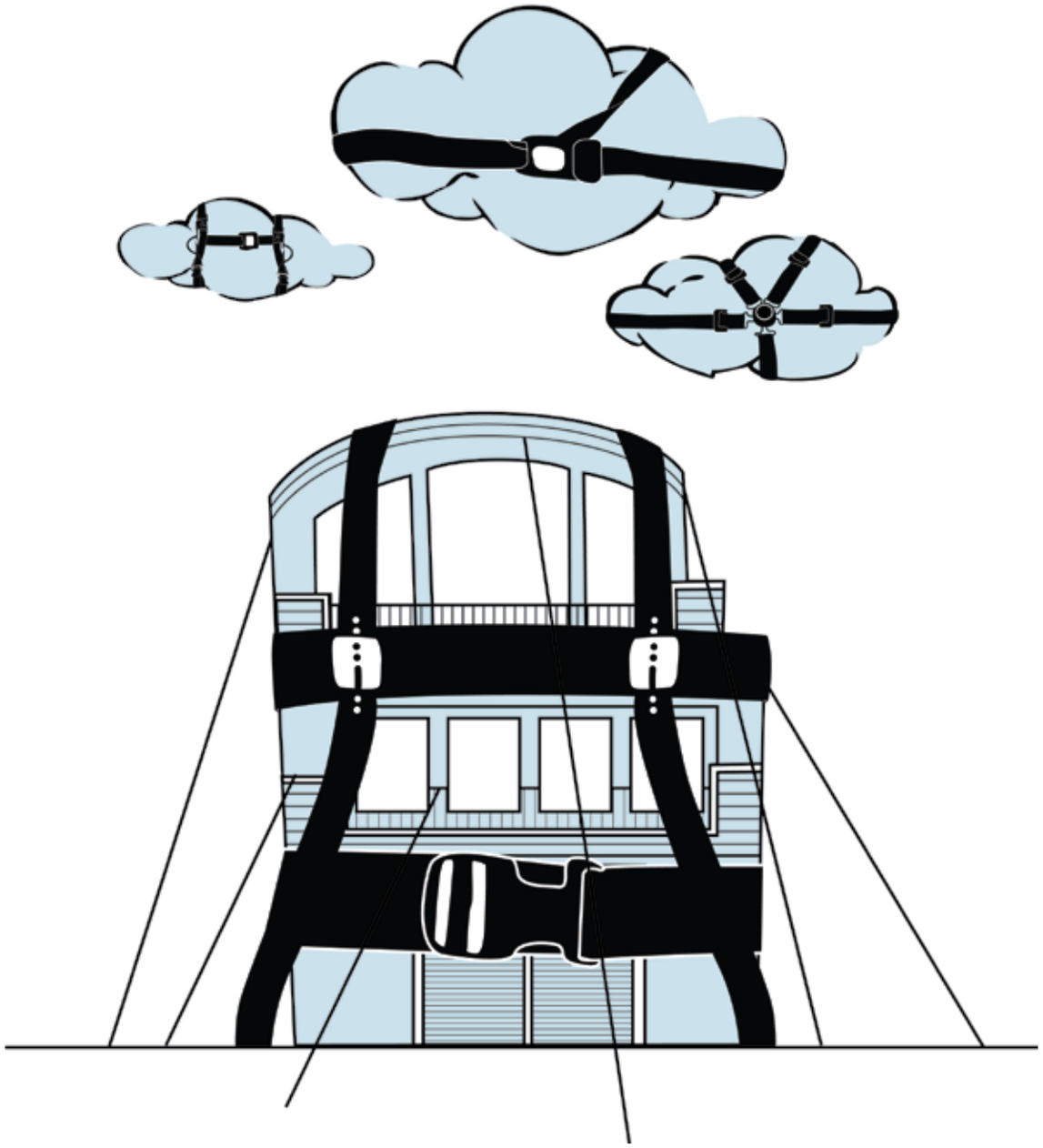
There are three earthquake engineering research centers around the country: in Buffalo, New York; at the University of Illinois at Urbana-Champaign; and the Pacific Earthquake Engineering Research Center (PEER), headquartered at the University of California, Berkeley. PEER organizes its research around the concept of performance-based earthquake engineering.

Performance-based engineering is a concept by which buildings are developed to a specific performance level. The designer or engineer works very closely with the building owner to decide what that owner needs to have in the way of performance after an earthquake. If the owner can tolerate a building that's down for the first six weeks, there's no reason to bring it up to a standard that keeps it functioning, especially when everything around it is nonfunctional. A lot of performance-based engineering takes a very broad perspective and looks at what will happen to the lifelines that the building depends on—the highways or other access to it, energy delivery systems, utilities, etc. Buildings are not islands, of course; they depend on all these other things to remain functional.

On the other hand, in the case of a hospital that has to remain functional, the engineer would design onsite energy facilities to keep the building up and running. Similarly, if it's a "just-in-time" production facility, there can't be any downtime whatsoever. The owner will want to have that building designed to levels that are far above normal building codes. An engineer can determine what needs to be done to get the facility to the level at which it will perform to the expectations of the owner.

This approach applies not only to new buildings, but to buildings that are being strengthened and retrofit. It really is the cutting edge of what's happening in engineering today.

Another very promising area is the work now being done on what are called "smart buildings" and "smart materials." Smart materials are composites that absorb large amounts of strain energy without deforming and will correct a building's response to an earthquake. For example, passive and active mass dampers, which act like muscles in that they flex and relax, are being put in a lot of very tall buildings around the world. The expectation is that the dampers will modify the way the buildings respond to energy and enable them to perform without damage. These are examples of exciting developments that have grown out of today's improved computational abilities and advances in composite materials. All told, if you're an experimental researcher, this is a period of great opportunity and promise.



Brenna Pribadi

THE FIELD ACT: BUILDING STRONGER SCHOOLS

Judith Lewis

For the past 75 years, public schools in California have been protected by special legislation mandating superior construction and inspection for seismic safety. Caltech's **Paul Jennings** and USGS scientist **Lucy Jones** weigh in on the law's significance and uncertain fate.

AFTER a 6.4 magnitude earthquake hit the city of Long Beach at 5:54 p.m. on March 10, 1933, California Assemblyman C. Don Field, a contractor from Glendale, was among the many who looked in horror at the city's ruined school buildings and registered a chilling thought: Five children had died in a school auditorium because the building had not been built to seismic standards. Had the temblor hit only a few hours earlier, thousands of children would have been killed within minutes.

In 1933, many of the state's schools were built of brick and mortar, with high ceilings and ornate exteriors, but little structural stability. Exactly one month after the earthquake, Field changed all that: He persuaded the California legislature to pass a bill that would require earthquake-resistant design for all the state's public schools. Later revised by the legislature, the Field Act, as it became known, requires state agencies to oversee the design and construction of public schools and hire an independent inspector to certify their integrity.

In 1992, the Field Act-certified Landers Elementary School was immediately habitable after a magnitude 7.3 earthquake opened a 12-foot crack in the earth at its rupture point. The school sat only one-half mile from the epicenter.

It has been an astonishing success. "The Field Act has probably saved more lives in California than any other act of legislation," says Caltech Provost Paul Jennings, a noted expert on how buildings respond to earthquakes. No Field Act building has ever failed in an earthquake. In the 1989 Loma Prieta earthquake, public schools in San Francisco's devastated Marina district served as sturdy emergency shelters while buildings around them crumbled and burned. In 1992, the Field Act-certified Landers Elementary School was immediately habitable after a magnitude 7.3 earthquake opened a 12-foot crack in the earth at its rupture point. The school sat only one-half mile from the epicenter.

THE Field Act has also paid off for the state's two-year community colleges, which were once part of the state's elementary and secondary educational system and remain subject to its laws. During the 1994 the Northridge earthquake, Pierce College and Mission College, both in the hard-hit San Fernando Valley, received the same "Intensity 9" shaking as did California State University at Northridge (CSUN). Pierce's buildings, most of which went up in the 1950s, sustained $5 million in damage; the newer Mission College came through without damage at all. CSUN, however, a state university subject only to the California Building Standards Code, saw its parking structure turn to rubble. Overall, the college sustained $400 million in damage.

"That's what inspection does for you,"says USGS seismologist Lucy Jones, who sits on the state's Seismic Safety Commission. "The Field Act works."

Success, however, does not easily translate into universal popularity. In recent years of seismic quiet and soaring construction costs, developers, builders, and representatives of the state's community colleges have chafed under the law's requirements, which they say slows down the construction of new colleges and prohibits the expansion of existing campuses into satellite structures.

"California's community colleges are vital to our educational system and to our communities," state Senator George Runner told his Lancaster constituents when he introduced legislation to exempt two-year colleges from the law in the spring of 2006. "It's important to end the greater regulatory burdens placed on community colleges in order to build and modernize facilities faster." Runner's bill was vetoed by Governor Arnold Schwarzenegger as "unnecessary," but only because similar legislation was in the offing: Embedded in a 2006 bill authored by Assembly Speaker Fabian Nuñez for the funding the construction of new K-12 schools was a single paragraph amending the state's education code to allow community colleges to choose between the Field Act or the California Building Standards Code

when building or remodeling. When the $10 billion bond measure sailed past voters in November 2006 as Proposition 1D, the provision was still deeply concealed within the bond measure's text; most voters thought they'd only elected to fund schools, not to exempt certain public buildings from longstanding seismic safety codes. "It wasn't in the voter pamphlet," Jones says. "There's no way voters could have known they were removing community colleges from the Field Act. But they did."

"In every gap between earthquakes people want to repeal the Field Act," Paul Jennings says. "They were doing it right before the San Fernando earthquake, and then they saw the wisdom of it when the school buildings came through well and other buildings didn't. Now we haven't had an earthquake since Northridge, and they're doing it again." Jennings believes, as do many Field Act defenders, that the problems with the law lie within the bureaucratic process, not the actual inspection and design requirements. "Engineers and architects grumble about the complexity that designing to it requires. But it's not really about the building standards. It's about the process they have to go through."

"IT does take forever to get new plans through all the steps," Jones admits. "It can take a year to get through the DSA [Division of the State Architect]," which is known to be an understaffed and underfunded office. But she insists the extra expense of the law is worth it. "Even with construction costs rising rapidly right now, the Field Act does not make a building that much more expensive; most estimates say it's just three to four percent," she says. "That's a very good long-term investment for the state of California, especially because we want to use these buildings for shelters after the earthquake."

Indeed, the last time then-Governor Gray Davis vetoed legislation similar to Nuñez's, as he did three times during his tenure, he cited exactly that function.

NOW all that stands in the way of relaxing seismic safety standards for community colleges is one small detail in the bond measure that could be used to challenge its legality: no one has explicitly stipulated who decides which building code to use. As a result, Runner has authored a bill to clarify that the Chancellor of the California Community College System would make that call. Facing widespread opposition from California Professional Firefighters, the California State Firefighters' Association, the California School Employees Association, and Services Employees International Union, Runner's bill has stalled.

Jones holds herself and the rest of the scientific community at least partially responsible that the law was called into question at all. "We haven't done a really good job of documenting what the Field Act has done," she says. "All the structural engineers know that it works, so they assume everyone else knows, too. When we proposed a study of it, one of our engineers asked, 'Why waste our money on studying a project we know is working?' I said 'Because it's not working politically.' And what we've seen is that politics matters."

MOVING A PALM TREE

FIFTH & CENTRAL
1888

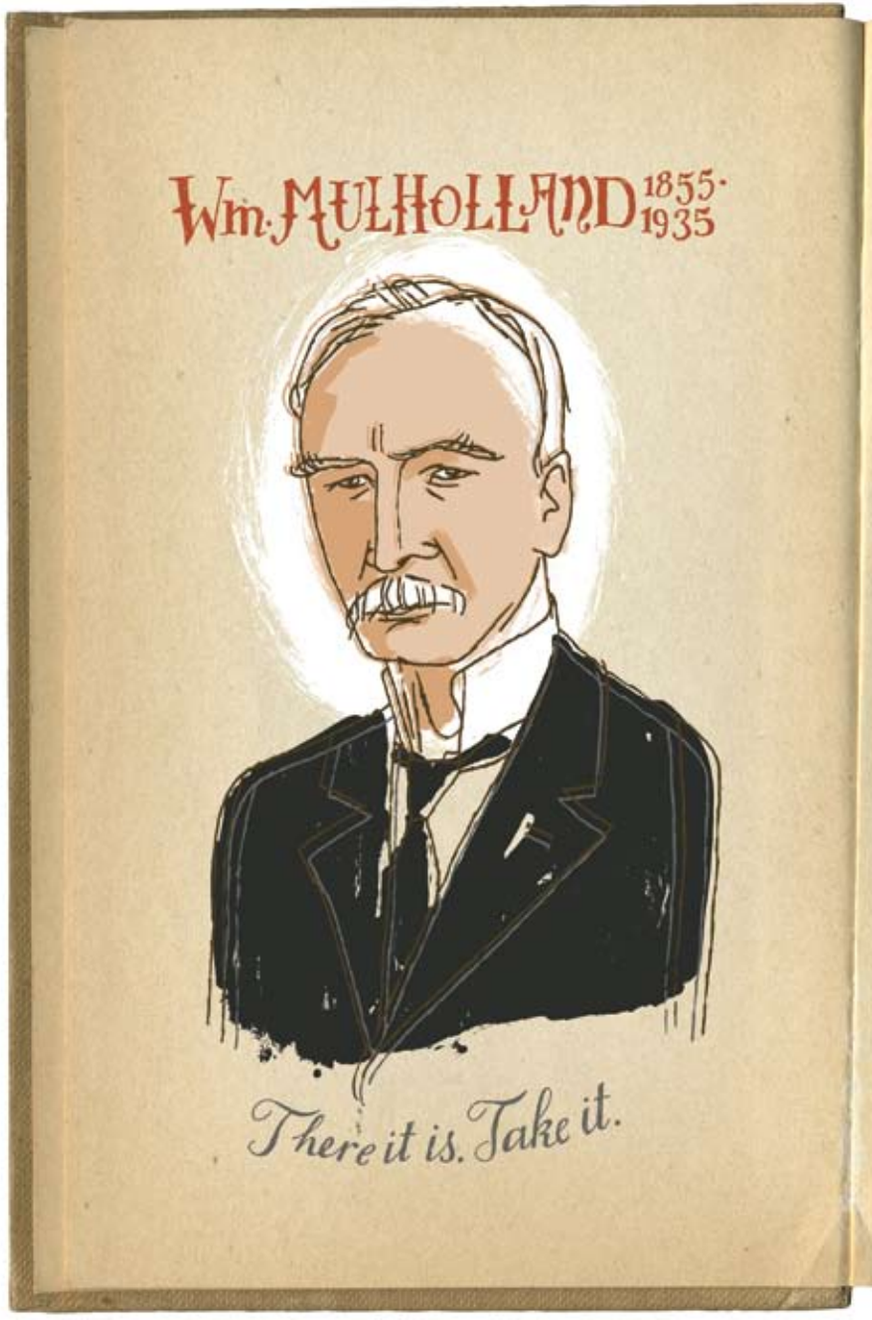
Paul Rogers

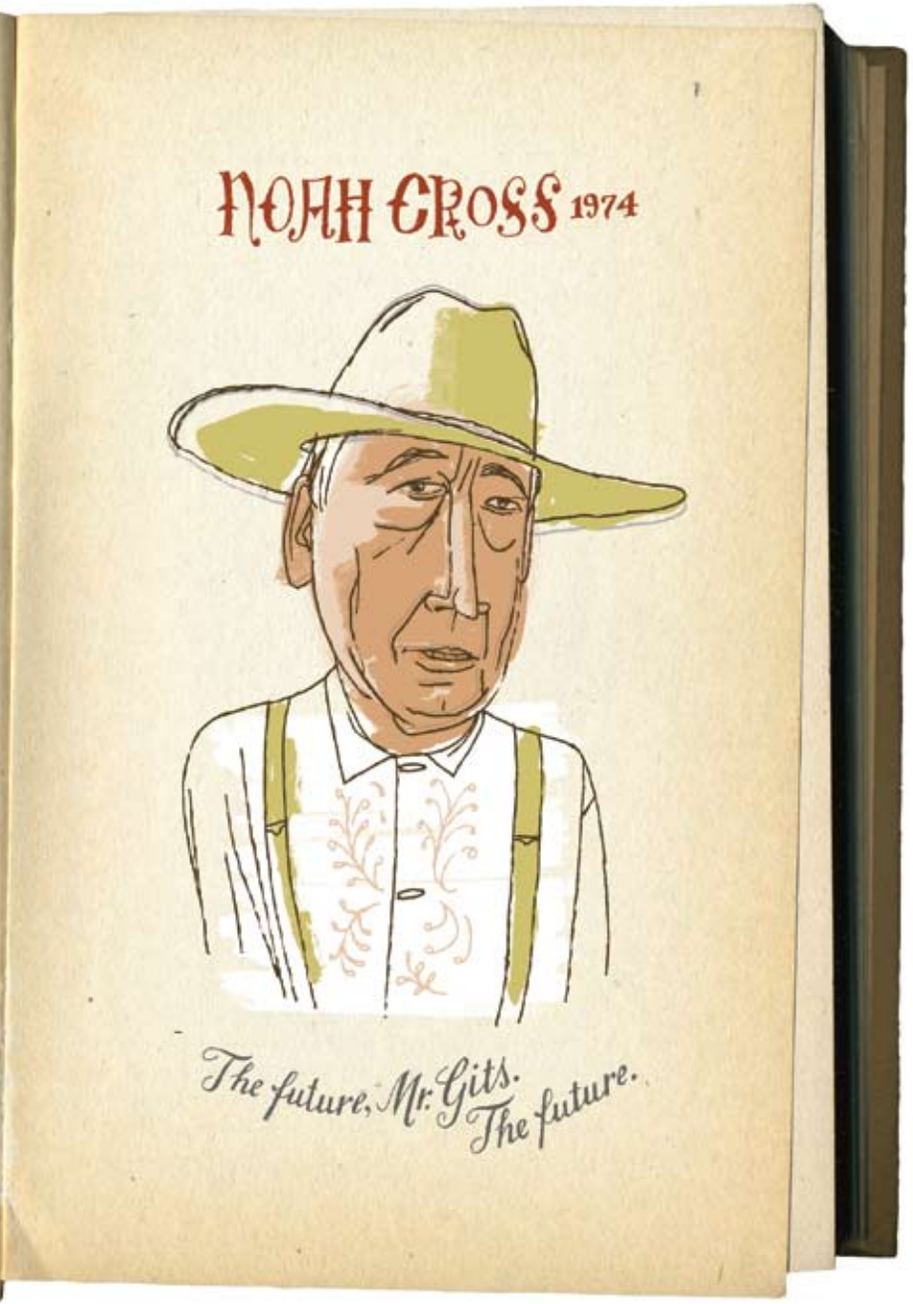
ANGEL'S FLIGHT 1901

DEMOLISHED 1969

"I WENT UP TO MY ROOM, UP THE DUSTY STAIRS OF BUNKER HILL, PAST THE SOOT-COVERED FRAME BUILDINGS ALONG THAT DARK STREET, SAND AND OIL AND GREASE CHOKING THE FUTILE PALM TREES STANDING LIKE DYING PRISONERS, CHAINED TO A LITTLE PLOT OF GROUND WITH BLACK PAVEMENT HIDING THEIR FEET."

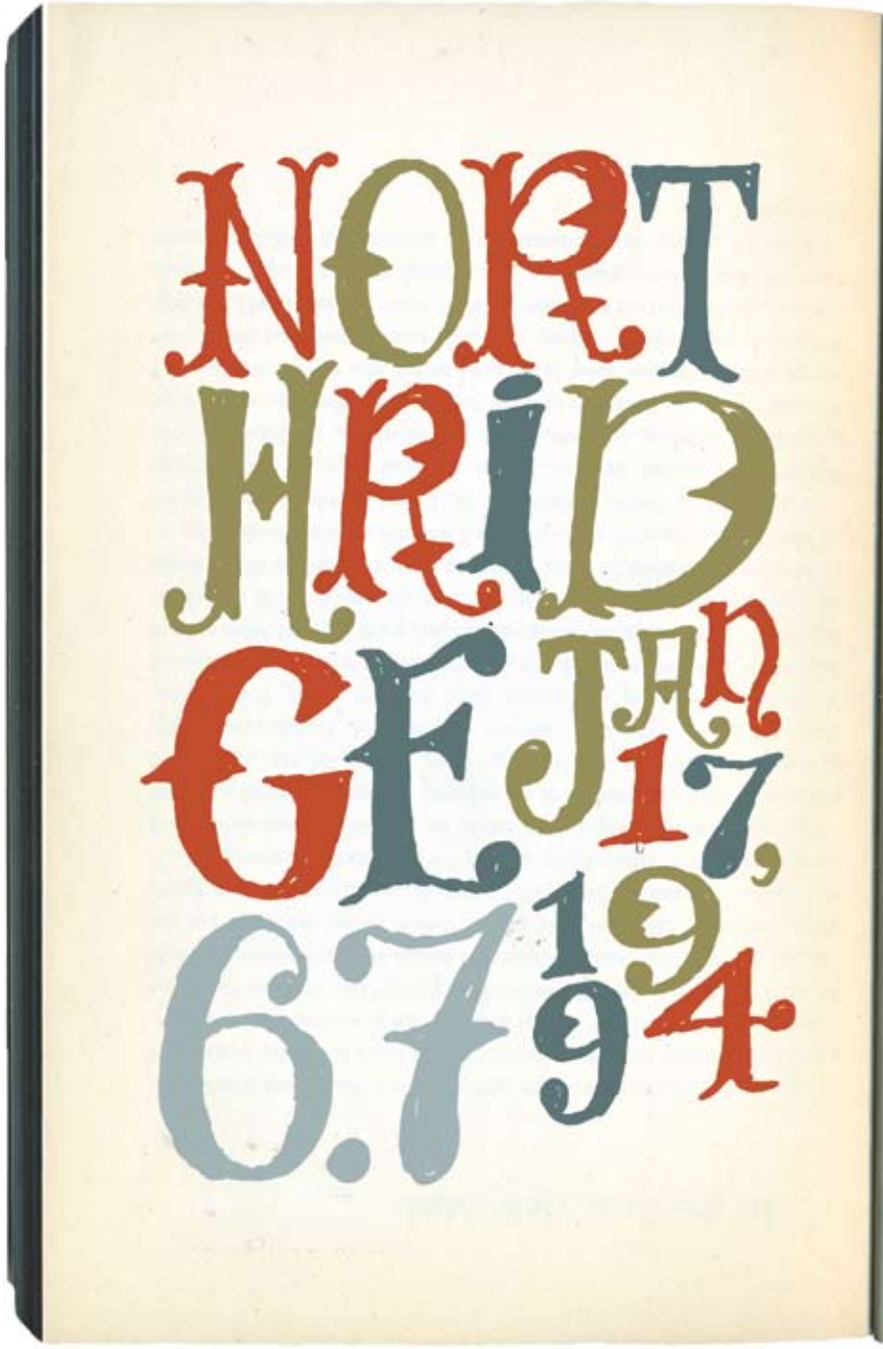
ASK THE DUST
JOHN FANTE 1939

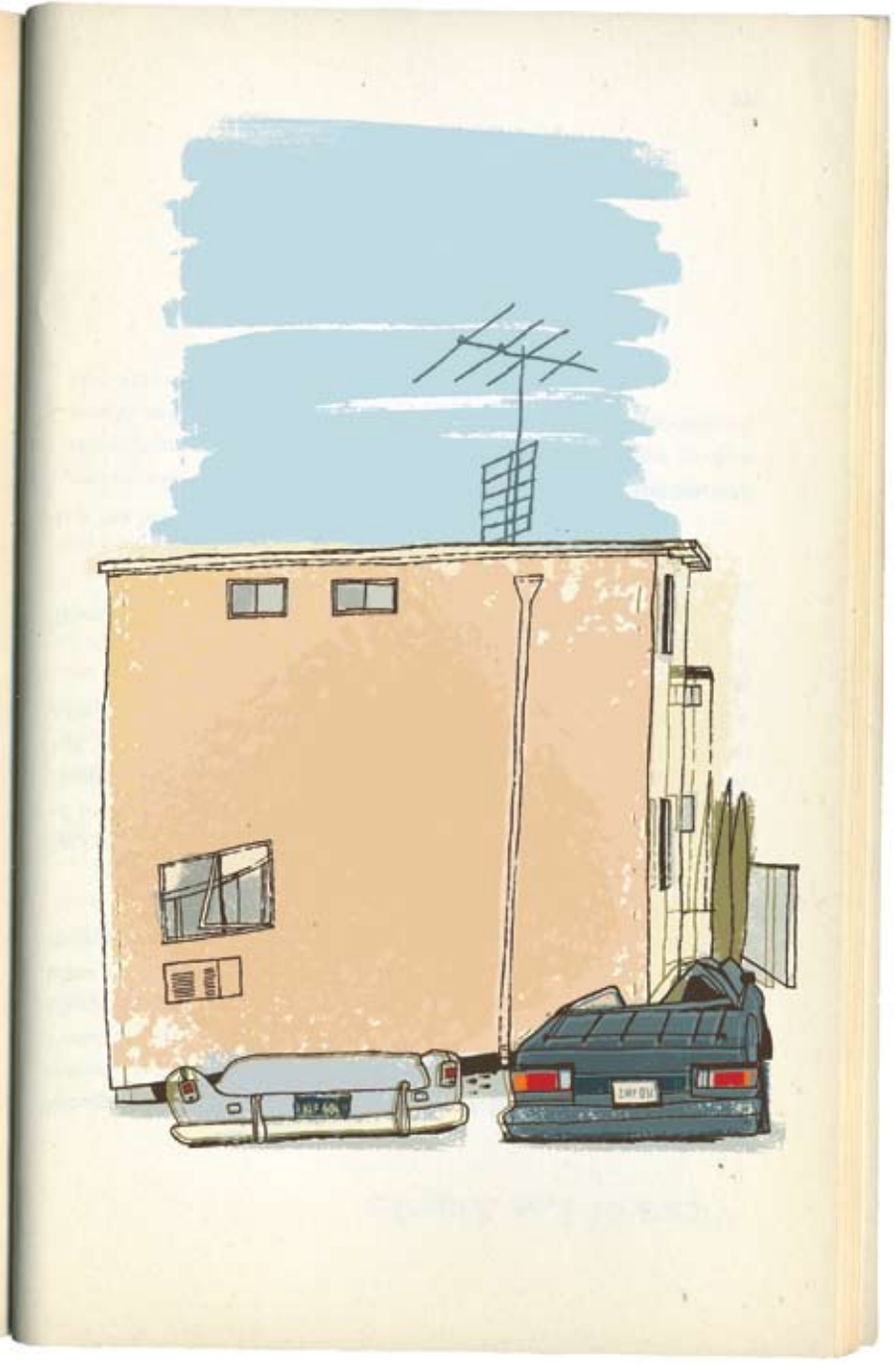

Wm. MULHOLLAND 1855-1935
There it is. Take it.


NOAH CROSS 1974
The future, Mr. Gits. The future.

THE PUP CAFE 12728 WASHINGTON BLVD
CULVER CITY, 1929 DEMOLISHED

MAY COMPANY
MIRACLE MILE 1939
AC MARTIN ARCHITECTS


NORTHRIDGE
JAN 17, 1994
6.7



GOD ONLY KNOWS,
GOD MAKES HIS PLAN.
THE INFORMATION'S
UNAVAILABLE TO THE
MORTAL MAN.
WE WORK OUR JOBS,
COLLECT OUR PAY,
BELIEVE WE'RE GLIDING
DOWN THE HIGHWAY
WHEN IN FACT WE'RE
SLIP SLIDIN' AWAY.

PAUL SIMON
SLIP SLIDIN' AWAY 1975

HOLLYWOOD HILLS 2007

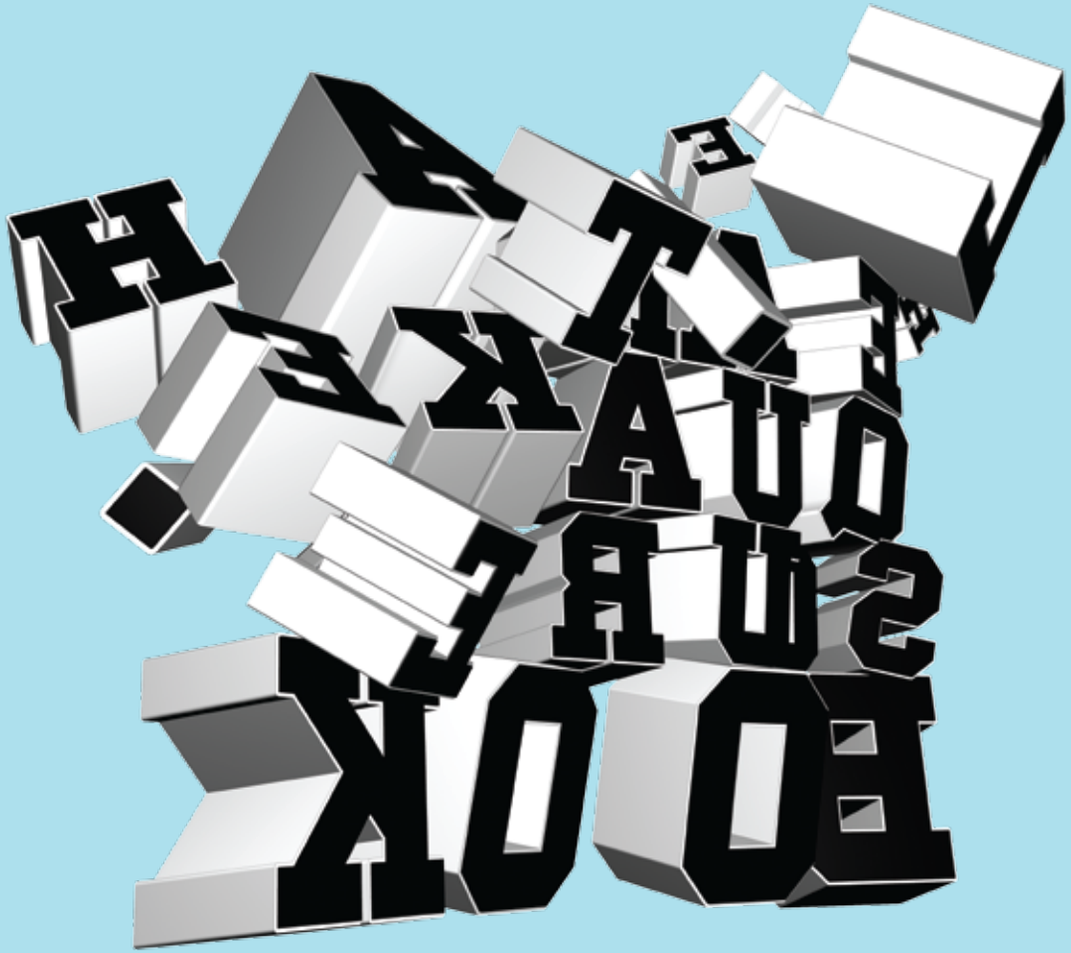
DULL FROM BEGINNING TO END

BUT LOADED WITH ENTERTAINMENT

ED RUSCHA

730 SOUTH BROADWAY

SECTION 3:
PREPARING FOR THE UNTHINKABLE



AT HALF-PAST TWO O'CLOCK of a moonlit morning in March, I was awakened by a tremendous earthquake, and though I had never before enjoyed a storm of this sort, the strange, thrilling motion could not be mistaken… Both glad and frightened, [I shouted]: "A noble earthquake! A noble earthquake!" feeling sure that I was going to learn something.

—John Muir, *The Yosemite* (1912)

IN the 1920s and 1930s, when a lot of new homes went up in Los Angeles, construction workers would slap a two-by-six on top of a freshly laid concrete foundation, and let it dry in the cement. They called that piece of wood a "mud fill," and they built the rest of the house on top of it.

"They figured it was a forever bond," says Shelly Perluss, the President of the Los Angeles-based Cal-Quake Construction. In 1933, they found out otherwise. Thousands of houses perched on mud fills slipped off their foundations. "So now we bolt the mud fill down and anchor the house." Among other things.

Retrofitting "isn't brain surgery," says Perluss. "But it is just a terrible job, physically speaking. You're working in an 15- or 18-inch crawl space; you can hardly move." People might do their own research on how it's done, but they still hire somebody else to do it. Current estimates run around $3,000 for a single-family home, and the rewards are tremendous. "We retrofitted a house for a couple thousand dollars before the Northridge earthquake over on Selma Avenue in Hollywood," Perluss says. "All the houses on the block were wrecked, but that one was picture-perfect. The president's wife came out to see it with a TV crew.

"I tell you, $100,000 of advertising couldn't have bought me the publicity that one house did."

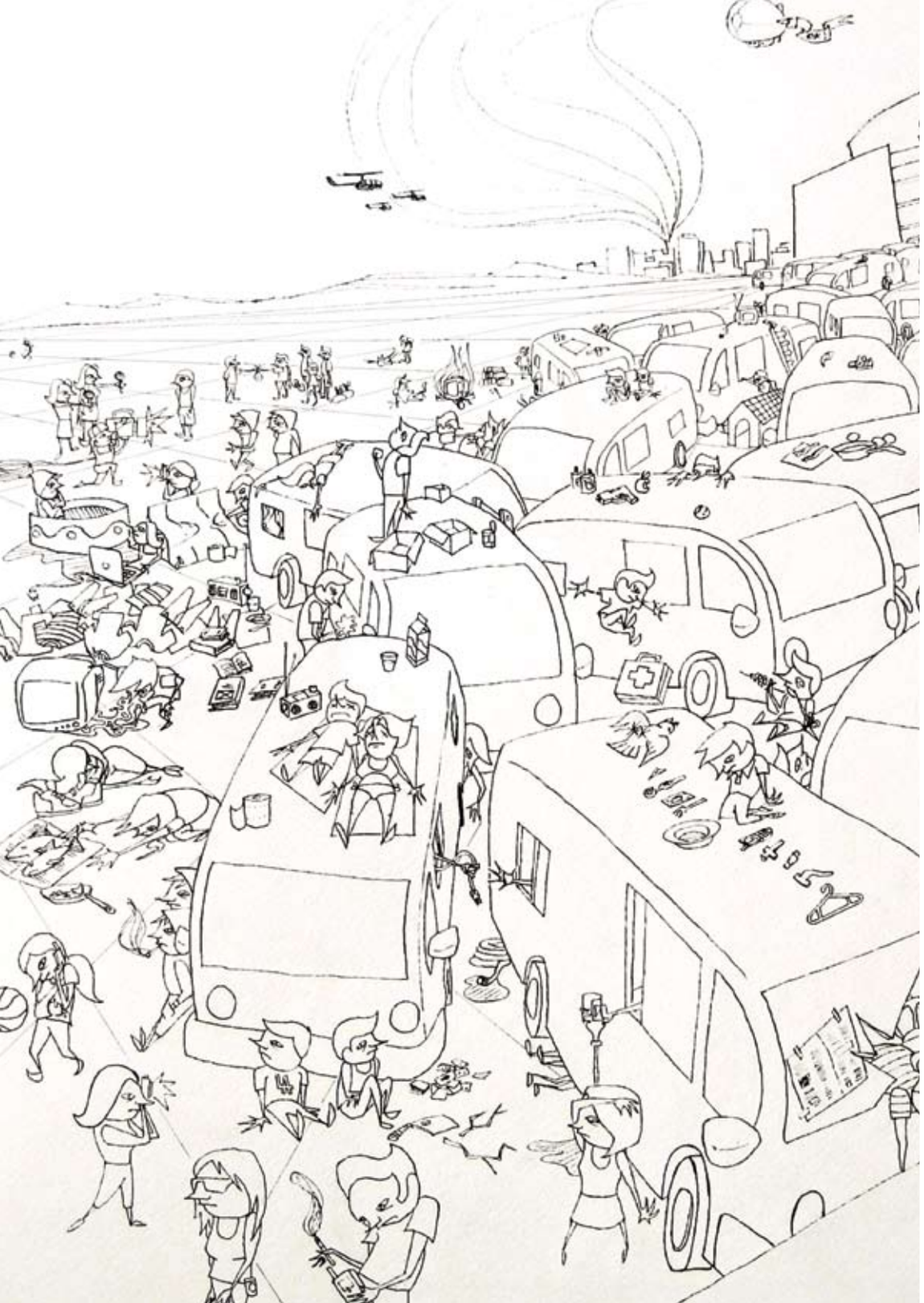
Perluss got a lot of business after the Northridge earthquake, "especially because FEMA was paying for it," he says. These days, he sees a little bump in business when a disaster happens elsewhere, as when Hurricane Katrina hit the Gulf Coast. For the most part, though, people have grown complacent.

"I'll tell you what happens," he says. "Somebody's asleep in Beverly Hills, and it's early in the morning, and they wake up and the world is shaking and they think they're going to die. Two minutes later it stops and they turn on the radio, and they hear it's a 6.7. And then they say, 'Oh, now I know what a 6.7 feels like!' But the answer is no, you don't: There's a guy over in Northridge who knows what a 6.7 feels like. The guy in Beverly Hills does not."

As Joan Didion says in the excerpt from her 1992 book *After Henry* that begins this section, there's something fatalistic about preparing for a disaster that may never happen. Preparing for an earthquake, from retrofitting your house to hoarding food and storing water, isn't like buying gas and boarding up your windows when you can watch on a radar as a hurricane roars your way. It's more like squirreling money away in your mattress, in small bills and coins, in case there's a run on the banks.

OH and by the way, you should do that, too: As University of California Los Angeles professor Linda Bourque notes in an interview here, ATMs probably won't work if the power goes out. Nor will your cordless phone.

"Preparedness" is a word used almost exclusively in the emergency-planning community, and you will find it repeatedly over the next few pages. Much of the current thinking on the topic has been influenced by the aftermath of Hurricane Katrina, when the world saw people stranded on their rooftops and abandoned in the Superdome. In an essay called "The Cultural Geographies of Disaster," University of Southern California geography professor Michael Dear bemoans the rise of "privatopia" and what it might mean for emergency planning; the California Seismic Safety Commission's Richard McCarthy explains how to sell the public on preparedness, and Dennis Mileti, an expert in the sociology of disaster planning, lays down a blueprint for a community that can weather disaster. At the end of this section, James Lee Witt, former head of FEMA, explains what it means to lead in a crisis—and beholds the miracle of a properly retrofitted home.



Anthony Van Groningen

Excerpt from

LOS ANGELES DAYS

Joan Didion

DURING one of the summer weeks I spent in Los Angeles in 1988 there was a cluster of small earthquakes, the most noticeable of which, on the Garlock Fault, a major lateral-slop fracture that intersects the San Andreas in the Tehachapi range, north of Los Angeles, occurred at six minutes after four a.m. on a Friday afternoon when I happened to be driving in Wilshire Boulevard from the beach. People brought up to believe that the phrase "terra firma" has real meaning often find it hard to understand the apparent equanimity with which earthquakes are accommodated in California, and tend to write it off as regional spaciness. In fact it is less equanimity than protective detachment, the useful adjustment commonly made in circumstances so unthinkable that psychic survival precludes preparation. I know very few people in California who actually set aside, as instructed, a week's supply of water and food. I know fewer still who could actually lay hands on the wrench required to turn off, as instructed, the main gas valve; the scenario in which this wrench will be needed is a catastrophe, and something in the human spirit rejects planning on a daily basis for catastrophe. I once interviewed in the late sixties, someone who did prepare: a Pentecostal minister who had received a kind of heavenly earthquake advisory, and on its quite specific instructions was moving his congregation from Port Hueneme, north of Los Angeles, to Murfreesboro, Tennessee. A few months later, when a small earthquake was felt not in Port Hueneme but in Murfreesboro, an event so novel that it was reported nationally, I was, I recall, mildly gratified.

A certain fatalism comes into play. When the ground starts moving all bets are off. Quantification, which in this case takes the form of guessing where the movement at hand will rank on the Richter scale, remains a favored way of regaining the illusion of personal control, and people still crouched in the nearest doorjamb will reach for a telephone and try to call Caltech, in Pasadena, for a Richter reading. "Rock and roll," the D.J. said on my car radio that Friday afternoon at six minutes past four. "This console is definitely shaking...no word from Pasadena yet, is there?"

"I would say this is a three," the D.J.'s colleague said.

"Definitely a three, maybe I would say a little higher than a three."

"Say an eight...just joking."

"It felt like a six where I was."

WHAT it turned out to be was a five-two, followed by a dozen smaller aftershocks, and it had knocked out four of the six circuit breakers at the A.D. Edmonston pumping plant on the California Aqueduct, temporarily shutting down the flow of Northern California water over the Tehachapi range and cutting off half of Southern California's water supply for the weekend. This was all within the range not only of the predictable but of the normal. No one had been killed or seriously injured. There was plenty of water for the weekend in the system's four southern reservoirs, Pyramid, Castaic, Silverwood, and Perris lakes. A five-two earthquake is not, in California, where the movements people remember tend to have Richter numbers well over six, a major event, and the probability of earthquakes like this one had in fact been built into the Aqueduct: the decision to pump the water nineteen hundred feet over the Tehachapi was made precisely because the Aqueduct's engineers rejected the idea of tunneling through an area so geologically complex, periodically wrenched by opposing displacements along the San Andreas and the Garlock, that it has been called California's structural knot.

Still, this particular five-two, coming as it did when what Californians call "the Big One" was pretty much overdue (the Big One is the eight, the Big One is the seven in the wrong place or at the wrong time, the Big One could even be the six-five centered near downtown Los Angeles at nine on a weekday morning), made people a little uneasy. There was some concern through the weekend

that this was not merely an ordinary five-two but a "foreshock," an earthquake prefiguring a larger event (the chances of this, according to Caltech seismologists, run about one in twenty), and by Sunday there was what seemed to many people a sinister amount of activity on other faults: a three-four just east of Ontario at twenty-two minutes past two in the afternoon, a three-six twenty-two minutes later at Lake Berryessa, and, four hours and one minute later, northeast of San Jose, a five-five on the Calaveras Fault. On Monday, there was a two-three in Playa del Rey and a three in Santa Barbara.

HAD it not been for the five-two on Friday, very few people would have registered these little quakes (the Caltech seismological monitors in Southern California normally record from twenty to thirty earthquakes a day with magnitudes below three), and in the end nothing came of them, but this time people did register them, and they lent a certain moral gravity to the way the city happened to look that weekend, a temporal dimension to the hard white edges and empty golden light. At odd moments during the next few days people would suddenly clutch at tables, or walls. "Is it going," they would say, or "I think it's moving." They almost always said "it", and what they meant by "it" was not just the ground but the world as they knew it. I have lived all my life with the promised of the Big One, but when it starts going now even I get the jitters.

Sung-Hae Baik

THE CULTURAL GEOGRAPHIES OF NATURAL DISASTERS

Michael Dear

MICHAEL DEAR is a professor in the Department of Geography at the University of Southern California. Among his many publications is *From Chicago to L.A.: Re-Visioning Urban Theory*.

PEOPLE love natural disasters. There is something irresistible about nature's power that humbles and stifles the capacity for reason. This is why people chase tornadoes or drive toward an impending volcanic eruption. Even when engulfed in disaster, some refuse to flee as they confront the prospect of their own demise. Such human responses to nature's calamities are deeply rooted in culture and geography.

Most places across the earth are exposed to some form of natural hazard, be it flood or drought, fire or avalanche. Yet not all places are equally threatened. A world map of seismic activity reveals a striking alignment of treacherous fault lines that accumulate at the continents' edges—carving, for example, a "ring of fire" that encircles the Pacific Ocean. This spectacular global jigsaw puzzle is the consequence of interlocking tectonic plates floating atop the earth's molten core.

Southern Californians live on one of the most prominent sutures in the earth's crust: the San Andreas Fault. Our destinies are tied to this fact of geography because, in a very elementary way, your chances of survival will depend on exactly where you are when a major earthquake hits. On one level, this is obvious: you will not escape if a freeway overpass collapses onto your car as it idles in traffic; but you might survive at least the initial shockwaves if you're in a building constructed to withstand extremes of tectonic movement. However, on another level, L.A.'s peculiar urban geography—namely its massive sprawl—may result in fewer deaths than might occur in other American cities where greater density presages concentrated catastrophe.

The simple lesson from years of privatization, criminal neglect and moral bankruptcy in Washington, D.C., is this: in any major disaster, we're on our own.

To understand this, consider that the urbanized portions of the five-county L.A. metropolitan region (Los Angeles, Orange, Riverside, San Bernardino, and Ventura counties) cover about 14,000 square miles and are home to about 17 million people in 177 cities. The impact of a major earthquake will inevitably be geographically uneven: that is, some places could be completely destroyed while others remain relatively intact. L.A.'s dense, distributed road transportation network will increase the opportunities for connecting between, escaping from, and bringing aid to stricken urban areas, as will the large number of regional airports in the Southland (the ports are another matter). In addition, since emergency services are already dispersed widely throughout the region, fire, police, and hospital services are more accessible to local needs.

These examples are not meant to induce complacency, nor do they tell the full story of potential disaster in Southern California. Instead, they call attention to some of L.A.'s geographic specificities that are critically important in emergency planning.

When confronted by the need to rebuild after a natural disaster, Americans traditionally turn to government. But, in this instance, sprawl may hinder speedy response because Southern California has such a crazy-quilt, fragmented political geography. Under normal circumstances, coordination among the 177 cities and five counties is virtually nonexistent; in an emergency situation, the region's pathological disconnectedness will likely exacerbate the anarchy of post-disaster panic.

IF local government is unable to keep up with disaster, can we rely on outside help from the federal government? In the aftermath of Katrina, only a fool would expect the feds to come to our aid (unless of course your brother happens to be president). In recent years, many federal emergency-response agencies, including FEMA and HUD, have been systematically dismantled and starved of funds. The simple lesson from years of privatization, criminal neglect and moral bankruptcy in Washington, D.C., is this: in any major disaster, we're on our own. (At 12:36 p.m. on April 23,

2007, a small temblor shakes the walls of my house as I write this essay, offering a stark reminder of the intimacy of earthquakes in everyday life.)

Since the Reagan presidency, it's been fashionable to blame government for all our ills, and 'privatization' became the mantra for deregulating everything from airlines to zoos. In my judgment, privatization is a political, economic and cultural disaster that is more threatening than any natural disaster, because it has all but eliminated our capacity to respond to disasters. During the year 2000, according to *The New York Times* (February 7, 2007), the federal government spent $207 billion on outsourced private contracts for work that hitherto had been undertaken by government. By 2007, the figure was $400 billion. In 2001, almost 80 percent of the contracts were put out for competitive bidding, but by 2005 only 48 percent were. As the *Times* puts it: ours is increasingly government of, by, and for private contractors. It is entirely plausible that the future mayor of an earthquake-devastated L.A. will bypass Washington, D.C., and beg for post-disaster aid from a Dubai-based megacorporation answerable only to its global shareholders.

BUT privatization is local, too. Almost 20 percent of the U.S. housing stock is now in 'common interest developments,' or CIDs, which house 57 million people in gated communities, condominiums, and the like. Legal scholar Evan McKenzie long ago called attention to 'privatopia,' a form of private urban governance that could lead to the demise of municipal government and local democracy. Needless to say, when things go wrong in CIDland (as they often do) adjacent municipalities are called in to fix things. If so many CIDers chose to abdicate from our communities, should we now mandate that their restrictive covenants include disaster planning? If yes, will their plan and its resources be limited to CID members only? If there is no disaster plan, why should CIDers who have opted out of our communities expect us to help them, or be entitled to that help? I don't have the answers to these questions, but we need to talk about privatopia, because things could get very ugly, very quickly following an earthquake.

IT comes down to this: all disasters are local. Los Angeles will remain highly prone to natural disaster and subject to the region's capricious urban geography. Cultural unreadiness of the kind I have described can only make coping with natural disasters worse, but cultural preparedness based on the region's real geographies could mitigate a catastrophe. The best plans are those informed by local knowledge, are locally inspired, and involve local coalitions. Without them, any personal preparations for post-earthquake survival could vanish quickly when fastidious, well-armed neighbors decide they prefer your brand of bottled water to theirs.

Katherine Siy

ASSESSING PREPAREDNESS

An interview with Linda Bourque by Aileen Farnan Antonier

LINDA B. BOURQUE, PhD, is professor in the Department of Community Health Sciences in the School of Public Health, University of California, Los Angeles. She is also the associate director of two centers: Southern California Injury Prevention Research Center, and Center for Public Health and Disasters. She has designed, conducted, and analyzed surveys of community perceptions of and responses to California earthquakes since the San Fernando earthquake of 1971. She talks to Aileen Farnan Antonier about who prepares and who doesn't, and why.

You have conducted surveys on earthquake preparedness issues for more than 30 years. What trends have you discovered?

There are some patterns that have been stable across all the studies we've done in terms of the type of individual most likely to prepare for an earthquake. People who have lived in California longer and who are more established have done more in terms of preparedness. More highly educated people, those with higher socio-economic status, and older people usually do more. Homeowners prepare more than renters do. Any differences across ethnic or racial categories are impacted by an individual's socioeconomic status and access to discretionary funds.

Were people were better prepared for the Northridge earthquake in 1994 than for the 1971 San Fernando quake?

After the San Fernando earthquake, our survey was shorter and very different from subsequent surveys, but indications were that people were well prepared before that earthquake. After 1978, when we adopted the basic questionnaire we still use, the data became more comparable, and we observed that the tendency for individuals to prepare had improved before both the Whittier and the Loma Prieta earthquakes. When we surveyed after Northridge, though, it appeared that the level of preparedness before that event had diminished.

In general, public authorities are not that good at being transparent because they think people will panic if they tell the public "too much." In fact, it's exactly the reverse. People do not panic. They want to know what to do if something does happen.

Now that it has been 14 years since the last major quake, I suspect the current level of preparedness is even lower than it was before Northridge. In the disaster business, we often talk about the window of opportunity right after an event. After Northridge there was a lot of discussion of earthquake preparedness. The *Los Angeles Times* published material on a daily basis for almost a year after the event. So during that window of opportunity the public is exposed to valuable information multiple times, and is provided with basic, helpful things to do. But then time passes, and competing priorities —jobs, kids, everything else—pushes preparedness to the back burner.

What can be done to keep preparedness at the front of the public's list of priorities?

It's an issue of not only providing people with information, but providing it repetitively and transparently. Tell them the whole story and be consistent over all the channels of communication. Give them ways to deal with what lies ahead. In general, public authorities are not that good at being transparent because they think people will panic if they tell the public "too much." In fact, it's exactly the reverse. People do not panic. They want to know what to do if something does happen.

Are any groups especially vulnerable during and after an earthquake?

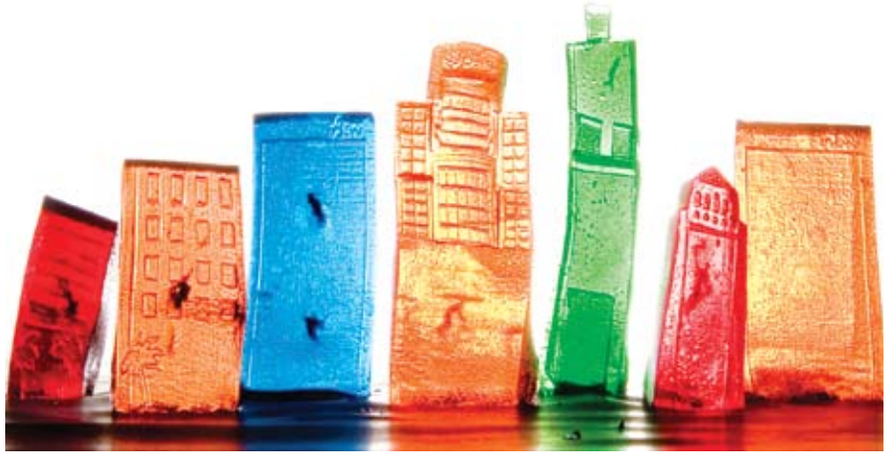
After Northridge, when we looked at the extent to which people knew about what help was available, there were strong differences between immigrant populations and non-immigrant populations. I further tried to bring out what we call "isolated individuals." Those who were speaking Spanish exclusively tended to be more isolated, and that correlated with recent immigrant status and less time in the state. Those linguistically isolated groups were less likely to know about resources, and that makes them more vulnerable.

If people could do only one thing to prepare, what would you recommend?

Have cash on hand, with change and small bills.

But whatever you do, you've got to build redundancy into your system. You can't depend on a single system; you've got to have a back-up. For example, a lot of people have relaxed about preparedness with the advent of cell phones. They think that with a cell phone they will be able to communicate easily in the event of an emergency. But the cell phone servers get overloaded immediately. And if electricity goes out, cell phone batteries cannot be recharged. People need to be encouraged to keep an old-fashioned landline—not a wireless, portable phone, but one that plugs directly into a jack in the wall. If electricity goes out, that phone line will still work.

Another thing is, yes, keep emergency bottles of water around, but also fill up your bathtub immediately after a quake. That way you have a secondary source of water. That's an easy one, and it doesn't cost you anything.



Mike Rios

Sul-Young Cho

HOW TO SUCCEED IN DISASTER READINESS

A profile of Richard McCarthy by Aileen Farnan Antonier

AS RICHARD MCCARTHY, the executive director of the California Seismic Safety Commission, tells Aileen Farnan Antonier in this interview, readying the public for disaster is a little like marketing soft drinks: You can't blame the customer if they're not buying. "We need creative people to sell this concept," he says. "They have to make it so cool that you can't stand going another day without being prepared." At the same time, he says, Hurricane Katrina taught public agencies that no one can go it alone: "The idea is to get industry and government to work together before the disaster occurs. Who knows how long it'll take FEMA to get here?"

Are Californians in denial about the "Big One"?

People have no concept of the catastrophe that's possible. If I could magically transport legislators and the public to the site of a major disaster, like what I witnessed after the earthquakes in Taiwan and Turkey, they would never view earthquakes and earthquake preparedness the same way. The misery is unforgettable: hundreds of thousands of people living in camps with no place to go, freezing to death in the winter; disease breaking out. When you come to a site with a collapsed school or hospital weeks or months after the event, and the bodies are still in there because the rescuers are focused on the living, it totally changes your perspective.

What will it take to keep people aware of the threat and motivated to take care of themselves and their communities?

There has to be a major paradigm shift, culturally. You need a big education program in schools, financial incentives for individuals, and the media talking about the threat we face everywhere you look. You have to tell people, from multiple sources, that they need to prepare—and it can't just be once every year.

The challenge is keeping the public aware of the threat when a major disaster hasn't hit California since Northridge in 1994. Right after an earthquake, you have a narrow window of opportunity—maybe three weeks. Then the next item in the news takes over. Because it's been so long since the last quake, the public has a hard time understanding the gravity of the threat. How are you going to motivate people—not to mention local governments—to do something if they think there's no risk? Politically, you have to have your list of recommendations ready to pull out and present right away after an event.

Who is to blame for the public's short attention span?

As part of the earthquake community, I say it's our fault because we're not communicating this issue to the public very well. Here's an example: For two years before the 100th anniversary of the 1906 San Francisco earthquake, we had been running television ads and placing educational pieces in newspapers. Museums mounted special exhibitions. On the anniversary, at a big conference at the Moscone Center, Mayor Gavin Newsom said something very interesting: "I really want to congratulate you all for the last two years and all the educational outreach things that you've done, but you need to know two things. First, 60 percent of San Francisco's current population wasn't here during the 1989 Loma Prieta earthquake. Second, as of today, our surveys say only 10 percent of the citizens of San Francisco are prepared." That told me that we've got to somehow convey our message differently. It's not the public's fault that they're not prepared, it's our fault.

So how do you get your message across?

It's like a Coca-Cola ad: you have to repeat it over and over and over again. I was in a meeting where the participants said, "Well, the public should take it upon themselves to be prepared, because it's the right thing to do." I said, imagine we're in Coca-Cola's boardroom right now. The CEO is looking at us, and saying, "Coke sales are going down." Do you think he's blaming the public? No. He's blaming the people sitting around the table. We're blaming the public, and

> **"Imagine we're in Coca-Cola's boardroom right now. The CEO is looking at us, and saying, 'Coke sales are going down.' Do you think he's blaming the public?"**

that's wrong. Our message has to be marketed with a Madison Avenue approach, by people who know how to do it effectively. And that's not the earthquake community.

The earthquake community in general—all of us: social scientists, earthquake engineers, geologists, medical personnel—is its own worse enemy in many ways. The community does not work as a single, focused

entity; it doesn't understand the political process at all. This group is not a player up in Sacramento, and we must now compete against many other societal problems for scarce resources. We don't recognize how decisions are made at the federal or state level very well.

To get people prepared, to get legislation passed, takes a different skill set. You need to go over to the legislative area of the capital and explain the issue to the people who are trying to address all of society's problems. We're competing against all the other social issues over there: homelessness, crack cocaine, avian flu, contaminated water, homeowners defaulting on mortgages. What's the crisis du jour?

Then we come in the door and say we are overdue for a major earthquake. "When is it going to happen?" they ask. Since it may never happen when they're in office, what are you going to say that will get them to rise above the fray and act?

What's the solution?

It's like a relay race: we need to hand off the information to professionals who know how to communicate to the public, and we then take a secondary role. We need creative people to sell this concept. They have to make it so cool that you can't stand going another day without being prepared. Get celebrities to say, "I'm worried for my family, and I've done what I can to prepare. And by the way, there are incentives from the government if you do it, too. Get your $1000 tax credit." And they have to say it over and over again.

Incentives are important in getting people to act. We know everybody's on a budget, so how do you get people to spend money on preparedness when they've got other financial pressures? When bolting the foundation doesn't increase the value of their house at all? You give that homeowner a $1000 tax credit, because they're not going to act on their own. We haven't demonstrated the cost-benefit of mitigation very well; that it's a good investment to retrofit your home.

Along with incentives, we need a big preparedness education program in our schools. Our country is recycling and wearing seat belts today because of education programs that started in schools. Japan is a good model for us, because the whole country sits either on a fault or a volcano, and is subject to earthquakes, eruptions, and tsunamis. Disaster preparedness is ingrained in them when they're very young, through educational programs. They have fantastic hands-on educational centers. The best one I've seen is in Shizuoka Prefecture, where they have big tsunami tank; a kitchen atop a shake table, so you can sit and experience different size earthquakes; a room where they teach you how to hold a fire hose as a team; and other learning experiences. As many as 500,000 school kids go through this disaster education center each year.

When you educate groups about earthquake preparedness, what do you tell them?

I call it yo-yo: "You're on your own." Out of 37 million people in the state, over half of them will be exposed to a major earthquake on the southern San Andreas Fault. There aren't enough first responders—emergency medical technicians, police, fire, and rescue—to go around. Chances are that if you need to be rescued from your home, your neighbors are going to do it. They know you're there. And your first meal is likely to come from your local church. Those are the true first responders within the community. Even if you're lying injured on your lawn, the fire department is going to focus on the retirement community or hospital down the block that's on fire. People need to understand that. So the public is really on its own for a number of days, at least a week. Everyone has to consider what we would need if we had no power, no water, and couldn't leave our houses for a week. This is the message we have to communicate, in all the different languages we speak in California, so that people can take action.

The other aspect people need to consider is personal and financial preparedness. Where are your credit cards, financial records, social

security numbers, and other critical documents such as insurance policies or your will? Keep a simple written record of what your assets are, where your investments are, and the codes associated with them. Not only do we have to be prepared with food, water, and medicines, but we also need to protect our identity and our financial well-being. Know where these things are: when you go to apply to FEMA for financial aid, you'll need all that paperwork.

What scenario keeps you up at night?

It's the concept of the cascading disaster. Let's say we have a big event on the southern section of the San Andreas—a magnitude 8. There are a couple of minutes of strong ground motion and all the damage that results. Then the fires start, fanned by the Santa Ana winds. Three or four days after that, dams fail, because they were weakened by the event, or from aftershocks. So now you have a flood, and evacuation concerns. It's not just the shaking; over time, one disaster begets another. That's what worries me the most—if the situation escalates out of control.

Has the devastation of Hurricane Katrina taught the state of California anything?

Absolutely. And a major event on the southern section of the San Andreas Fault would far exceed the damage Hurricane Katrina did.

After Hurricane Katrina, it became obvious that no one agency can do it alone. I attend meetings with groups of companies and organizations to see how best to work together in state-private partnerships. The idea is to get industry and government to work together before the disaster occurs. Get the partnerships established up front, with the roles well defined, and the resources identified. Who knows how long it'll take FEMA to get here? It's pretty obvious the state is on its own for some time in a disaster.

Until Governor Schwarzenegger came along, it was difficult to form partnerships with industry. The idea that private partners might make money from participating in preparedness endeavors or receive positive press was somehow considered unseemly. But if they're going to participate, they should get something more than just positive press. If someone invents or develops something that saves lives and also makes money, why not? Whoever invented automobile airbags is making money. No one is calling them greedy. It's a philosophical shift.

After Hurricanes Rita and Katrina, the issue of evacuation was highlighted. The common wisdom has been that you "shelter in place" for an earthquake, but that may not necessarily be true. You have to consider subsequent problems, such as floods or fires. If a fire is spreading through an urbanized area, there will be a need to inform people they have to leave: pack one bag and get on the bus. As we saw in Katrina and Rita, you never know how far you'll have to go. It's an interesting challenge. Everyone's going out of Los Angeles, and no one's coming in. All the freeway traffic is flowing east towards Las Vegas.

We need to send a message to the public that the preparedness actions you take now can mostly apply for all disasters. Should an event occur on the southern segment of the San Andreas Fault, this is what you should do, but these actions will also prepare you for other types of disasters: fires, floods, tsunamis, terrorism. We've got to join forces with all the other hazards experts and get more bang for the buck. After 9/11 and Katrina, we all know we need preparedness on a different scale.

Sung-Hae Baik

EARTHQUAKE DISASTERS BY DESIGN

Dennis S. Mileti

DENNIS S. MILETI is professor emeritus at the University of Colorado at Boulder, where he served as chair of the Department of Sociology and as director of the nation's clearinghouse for natural hazards knowledge in the social and behavior sciences, The Natural Hazards Research and Applications Information Center. He currently serves as vice chair of California's Alfred E. Alquist Seismic Safety Commission. His essay is a map for the kind of sustainable, long-term thinking that leads to community resiliency.

MOTHER Nature causes earthquakes, but earthquake disasters are largely the result of the actions and inactions of people. Narrow and shortsighted development patterns, cultural premises, and attitudes toward the natural environment, science, and technology all contribute to society's responsibility for the disaster that unfolds after an earthquake occurs. Consequently, we must find a way to force people to own up to the fact that humanity designs future earthquake losses through its daily decisions, and to link earthquake hazard mitigation to sustainable development.

One problem is the fallacy underlying many of the accepted methods for coping with earthquakes: the idea that people can use technology to control nature and render themselves safe. What's more, most strategies for managing all natural hazards have followed a traditional planning model: study the problem, implement one solution, and move on to the next problem. This approach casts the earthquake hazard as static and mitigation as a positive linear trend. But recent disaster events have shown that natural disasters of all kinds are not linear problems that can be solved in isolation.

Another problem is that some efforts to head off damages only serve to postpone them. For example, communities build stronger buildings to avoid losses from future earthquakes. But such communities often have more property to lose when the forces of nature exceed the resistance built into structures because additional development occurred that counted on the assumed protection. To redress those shortcomings, a shift is needed toward sustainable earthquake hazard mitigation that links natural resources management with local economic and social resiliency, viewing this mitigation in a larger context.

A new approach to the earthquake hazard

Any shift in strategy must cope with the complex factors that contribute to earthquake disasters in today's—and especially tomorrow's—world. Here are the main guidelines for improving our ability to mitigate hazards.

Adopt a global systems perspective.

Earthquake disasters arise from interactions among the earth's physical systems, its human systems, and its built infrastructure. A broad view that encompasses all three of these dynamic systems, and interactions among them, can enable us to find better solutions.

Accept responsibility for earthquake disasters.

Human beings—not nature—are the cause of earthquake disaster losses, which stem from choices about where and how human development will proceed. We must also accept that there is no final solution to the earthquake hazard since, ultimately, technology cannot make the world safe from the forces of nature.

Anticipate ambiguity and change.

The view that natural hazards are relatively static has led to the false conclusion that any mitigation effort is desirable and will—in some vague way—reduce the grand total of future losses. In reality, change can occur quickly and nonlinearly. Human adaptation to earthquakes must become as dynamic as the problems presented by the earthquake hazard itself.

Reject short-term thinking.

Mitigation, as frequently conceived, is too shortsighted. In general, people have a cultural and economic predisposition to think primarily in the short term. Sustainable earthquake hazard mitigation will require a longer-term view that takes into account the overall effect of mitigation efforts on this and future generations.

Account for social forces.

Societal factors, such as how people view the earthquake hazard and mitigation efforts or how the free market operates, play a critical role in determining which steps are actually taken, which are overlooked, and thus the extent of future disaster losses. Because such social forces are now known to be much more power-

ful than disaster specialists previously thought, growing understanding of physical systems and improved technology cannot suffice. To effectively address natural hazards, mitigation must become a basic social value.

Embrace sustainable development principles.

Earthquake disasters are more likely where unsustainable development occurs, and the converse is also true: disasters hinder movement toward sustainability because, for example, they degrade the environment and undercut the quality of life. Sustainable mitigation activities should strengthen a community's social, economic, and environmental resiliency, and vice versa.

Fostering local stability

Sustainability means that a locality can tolerate—and overcome—damage, diminished productivity, and reduced quality of life from an earthquake without significant outside assistance. To achieve sustainability, communities must take responsibility for choosing where and how development proceeds. Toward that end, each locality evaluates its environmental resources and hazards, chooses the future losses that it is willing to bear, and ensures that development and other community actions and policies adhere to those goals.

Six objectives must simultaneously be reached to mitigate earthquake hazards in a sustainable way, and stop the trend toward spiraling catastrophic losses from earthquakes and other natural disasters.

Maintain and enhance environmental quality.

Human activities to mitigate natural hazards should not reduce the carrying capacity of the ecosystem, for doing so increases losses from hazards in the longer term.

Maintain and enhance people's quality of life.

A population's quality of life includes, among other factors, access to income, education, health care, housing, and employment, as well as protection from disaster. To become sustainable, local communities must consciously define the quality of life they want and select only those mitigation strategies that do not detract from any aspect of that vision.

Foster local resiliency and responsibility.

Resiliency in the face of a disaster means a locale can withstand an extreme natural event with a tolerable level of losses. This resiliency requires mitigation actions consistent with achieving that level of protection.

Recognize that vibrant local economies are essential.

Communities should take mitigation actions that foster a strong local economy, rather than detract from one.

Ensure inter- and intra-generational equity.

A sustainable community selects mitigation activities that reduce hazards across all ethnic, racial, and income groups, and between genders equally, now and in the future. The costs of today's advances are not shifted onto later generations or less powerful groups.

Adopt local consensus building.

A sustainable community selects mitigation strategies that evolve from full participation by all public and private stakeholders. The participatory process itself may be as important as the outcome. A long term, comprehensive plan for averting disaster losses and encouraging sustainability can offer a locality the opportunity to coordinate its goals and policies. A community can best forge such a plan by tapping businesses and residents as well as experts and government officials. And while actual planning and follow-through must occur at the local level, a great deal of impetus must come from above. Nothing short of strong leadership from state and federal governments will ensure that planning for sustainable earthquake hazard mitigation and development occurs.

BOLD LEADERSHIP IN CRISIS MANAGEMENT – A CALL TO ACTION

Josh Tetreault & Andrew Holder & John-Everette Perry

James Lee Witt

UNDER James Lee Witt, the Federal Emergency Management Agency went from being a moribund bureaucracy to an international leader is crisis management. During his tenure, which lasted from 1993 until 2001, Witt oversaw relief efforts for more than 350 federally declared disasters; coordinated response and recovery operations for a dozen deadly hurricanes; and helped put the city of Los Angeles back on its feet after the country's most costly earthquake, Northridge in 1994, leveled freeway overpasses and destroyed thousands of homes and commercial structures. Witt

is currently chief executive officer of James Lee Witt Associates, which assists state and local governments in emergency. The essay below is partially adapted from his 2002 book, with James Lee Morgan, *Stronger in the Broken Places: Nine Lessons for Turning Crisis Into Triumph.* The editors thank Mark Ghilarducci, vice president and director of the Western States Regional Office, and M. Reginald B. Salvator, program specialist, both of James Lee Witt Associates, for their invaluable contributions to this essay.

FIFTEEN years ago, when President Clinton appointed me director of FEMA, somebody asked me what he had meant by describing me as "a man of uncommon common sense." I didn't know how to answer, admitted as much, and said I would think on it.

What I came up with was this: In 1960, when I was 16 years old, I bought my first car, a 1951 Ford that squawked rubber in all three gears. I paid $250 for it, money I had earned baling hay in Texas the summer before. I was very proud of that old car. It was sky blue with a flat-head V-8 and twin pipes, and in it I felt like the coolest boy in all of Dardanelle, Arkansas.

One night, leaving the roller rink, the engine started making a terrible racket. I was a farmer, not a mechanic, but even I knew what that metal-on-metal sound meant: I had thrown a rod. The car was undriveable, so I got a buddy to hook a chain to my bumper and tow me home. We hauled the Ford down to the barn and parked it under the shed. My dad came out and looked at it. He hadn't been all that big on my buying a car in the first place.

"What you gonna do now?" he said.

"Well, Dad," I said, "I guess I'll fix it."

Now, I need to step back here and make a point, which is that when my car broke down, hiring somebody else to fix it was out of the question. I grew up the son of an Arkansas sharecropper. Until I was 15, we had no indoor plumbing and only a coal stove for heat. In the winter, my dad would spread sheets of linoleum on the floor to block out the cold air, and to this day I can see that linoleum floating up whenever a harsh wind blew. My mother was a housekeeper, at first just for us and then for other people, too, and my brother, sisters, and I helped her as well. She made our clothes out of flour sacks, and I soon learned not to object whenever she asked me to go grocery shopping with her. That way, I at least got to choose the color of my next shirt.

Procrastination is the arch-enemy of crisis management. Sometimes a crisis becomes a crisis simply because someone has failed to act.

I don't mean to make my early life sound unduly harsh. We were a close family, and we had plenty of good times. Still, by age 16, I had seen my father and mother survive not just the expected hardships of farm life, but also the tornado that turned our house on its foundation when I was five, the fire that destroyed everything we had when I was 15, and the other tornado that we escaped only by running to a nearby storm shelter, with my mother getting bitten by a snake on the way.

I had never torn apart an engine, but the next morning I set to work on it. I jacked the car up on blocks, took off the heads, took off the oil pan, took out the crankshaft, and took out all the pistons and rods—everything, until that engine block was clean as a whistle. Then I turned the crankshaft, turned the rods, put in new rod bearings, and put the whole engine back together. I still had a little coffee can full of bolts leftover, but the car

seemed to run fine. I never figured out what whose extra bolts were for.

FOR years, I didn't realize there was anything particularly remarkable about that event. But what I now see as remarkable is that I knew I could fix it. Having watched my parents fight their way through bad times, and having endured many dicey moments myself, I've come to believe that "uncommon common sense" is nothing more than a bone-deep faith in your ability to cope in a bad situation: faith that you can decide what to do, you can figure out how to do it, you can pick up the pieces of your life and go on. It's frightening the first time you have to tap into that confidence at your core. But the more you're tested, the more you can rely on your experience at tapping into it. You don't have to be afraid that it'll fail you. Whatever it is inside us that instills, facilitates, and conveys such confidence, the truth is that it grows, like bark, with every trial you face.

Unfortunately, common sense is a commodity that seems to be in extremely short supply, especially in organizations. Leon Panetta, former congressman and White House chief of staff, says, "Democracy operates either through crisis or leadership." I think you could say the same for corporations, communities, and even families.

We tend to toss the word crisis around pretty loosely, to the point that it sometimes covers everything from death to dentures. But my dictionary defines crisis as "a crucial or decisive point or situation: a turning point." Crises are turning points—defining moments in our lives when we can choose to lead.

LIFE does—must—go on, a fact that cuts to the heart of what I mean when I say "handling crisis." Rudyard Kipling wrote about keeping your head while all around you others are losing theirs. That's part of what I mean—maintaining a presence of mind, and a sense of proportion, in the midst of the worst calamities. Some people are constitutionally better suited for this than are others, but there are skills that can be taught—about such things as team building, prioritizing, support groups, and even self-discipline. Remember this above all: Procrastination is the arch-enemy of crisis management. Sometimes a crisis becomes a crisis simply because someone has failed to act.

DURING my eight years at the Federal Emergency Management Agency (FEMA), I managed 373 major disasters, including 54 tornadoes, 43 floods, 38 hurricanes, four earthquakes, and one terrorist bombing. Having the word "crisis" in your job description means you get to see people at both their worst and their best—often at the same time. Watching so many ordinary humans deal with extraordinary circumstances, I absorbed a certain gut-level understanding of why some people are able to manage crisis—practically, emotionally, and spiritually—and others aren't.

In a disaster, we tend to think in terms of groups; 20,000 survivors in a shelter, for example. But those are 20,000 individuals who look at the world through only their own eyes. Crisis management is, at heart, an individual challenge.

Groups don't think; they react. More than that, they fantasize, imagine, fear, fabricate, compete, compensate, placate, and supplicate. With their many arms and legs flailing wildly, they wrestle with illusions. When I joined FEMA, the agency itself was in crisis. Widely known as a do-nothing outfit—the government's "turkey farm"—it was in real danger of being dismantled by Congress. Originally set up to guard against nuclear war, FEMA was once little more than a dumping ground for political appointees. But short-sightedness always reveals itself. When Hurricane Hugo hit South Carolina in 1989, FEMA's response was so slow and cumbersome that Senator Ernest Hollings called the agency "the sorriest bunch of bureaucratic jackasses I've ever known." Unfortunately, that wasn't the agency's low point.

That came in 1992, when Hurricane Andrew devastated South Florida. FEMA was so inept in acting that people were still living in tent cities more than a year after the storm.

MY task as director was clear: to slash red tape and redefine how the federal government responds to crises in its citizens' lives. Most important was to shift the agency's thinking away from simply dealing with a disaster, to actually trying to prevent, or at least to lessen the impact, of one. On the most practical level, disaster management professionals divide their work into four phases: response, recovery, preparedness, and mitigation.

Response is the most reactive. Say a tornado tears through a community, wreaking havoc and perhaps death for miles. In the response phase, you go out and look at the situation and see what's needed, from blood supplies to bottled water to shelter (not to mention ministers, psychologists, and financial counselors). Response is crisis management in its most stripped down, basic, and most unimaginative form. It's getting the victims the help they need as fast as you can.

Recovery is returning the victims to some sense of normalcy. It is as much a goal as a process. From a long-range standpoint, recovery will certainly require financial assistance and may necessitate psychological counseling. Short term, it involves everything from debris removal to clothing donations to house rebuilding. I also find that it helps to give people a place to attend church services, even if their house of worship has been blown to kingdom come.

Preparedness is the pivotal step between recovery and prevention. In the case of floods, after a few of them, your experience tells you that another one is going to wash over you someday, so you set in place procedures for when that bad day finally arrives. By then you've got a pretty good sense of what you need to stockpile—fresh water, say, and sandbags—and what emergency services you need to have on standby. In August 1993, FEMA even took the then-revolutionary step of deploying trucks, crews, and supplies (generators, cots, chainsaws, water, bedding, tents) to Raleigh, North Carolina, in anticipation of Hurricane Emily's arrival on the North Carolina coast. Sometimes hurricanes don't follow the routes or schedules the forecasters have mapped out for them, and if Emily had missed North Carolina we might have been criticized for jumping the gun and wasting taxpayers' money. But Emily did hit, and we were heroes because we were prepared.

IN the end, though, mitigation—which means to moderate in force or intensity—should be the goal of every crisis manager. Why prepare to clean up more efficiently after a disaster when you can prepare to lessen its effect in the first place? I learned that a long time ago in Yell County, Arkansas, when I was county judge, the official in charge of the roads. We had a big flood that washed away 33 of the county's wood bridges, which put us in quite a fix. When FEMA came to survey the damage, they would only pay us to replace the same kinds of bridges we had. "That's crazy," I said. "Are you telling me that you'd rather replace wooden bridges over and over instead of building bridges that won't wash away?" They wouldn't budge. So we took the money they gave us and raised extra money to build new bridges out of steel and concrete. That was almost 20 years ago, and every one of those bridges is still standing. Mitigation is the ultimate application of common sense to the challenges the world throws our way.

As Director of FEMA, I had the privilege to help change the way the United States thinks about disasters. Four specific ideals were central to my efforts in making preparedness, prevention and mitigation target focuses of emergency management:

- Strong and rigorously enforced building codes
- Public-private partnerships
- Leadership
- Personal and community education and planning

In the aftermath of the Northridge earthquake, I was with then-First Lady

Hillary Clinton touring a neighborhood that was devastated—all except for one home whose owner was sitting outside on his front lawn. I asked why his home was the only one on the block that did not have any damage. He said he had gone to the library and checked out a book on how to perform an earthquake retrofit on his home. When I asked how much the retrofit cost, he said $1,500.

States such as California have adopted some of the most stringent earthquake building codes in the country. It is important that other states, and countries, adopt similar strong building codes and enforce them. But what is more critical is that they go back and look at buildings that were built before stronger building codes were adopted. We have inherited a traditional building stock in earthquake- and flood-risk areas that will cost an astronomical amount of money to replace, particularly when you have a disaster.

Since we have both community and individual responsibility to do all we can to save lives, protect our families, keep businesses open, protect jobs and our environment, building stronger, disaster-resistant buildings is critical. Buildings can be retrofitted to resist an earthquake—a life-safety retrofit—and I have seen many businesses and homes that survived major earthquakes because they were either built right or retrofitted.

I'LL never forget visiting several schools after Northridge and seeing the suspended ceilings and light fixtures that had fallen on the children's desks. If school had been in session when the earthquake struck, who knows how many children would have been hurt or killed? In the aftermath of the quake, many Los Angeles area hospitals also had to be evacuated because the facilities were unsafe. We helped to rebuild those schools and hospitals to reduce the chances that the light fixtures will hurt children and to ensure that hospitals will remain open and will continue to serve their communities when another disaster strikes.

In 2004 and 2006, California voters approved a series of general obligation bonds that would, among other things, assist children's hospitals (Prop. 61, $750 million, in 2004) and public schools (Prop. 1D, $10.4 billion, in 2006) to retrofit existing facilities as well as build new facilities using updated building codes. While these actions are a great start toward ensuring our hospitals and schools hold up during an earthquake, much more still needs to be done. I have seen the consequences of building codes in every type of disaster, and have learned a pretty simple formula: When a disaster hits, buildings with locally enforced building codes suffer far less damage. Structures built to strong codes still stand. People who live and work in them are still alive.

ONE year after Northridge, an earthquake struck Kobe, Japan, and caused the destruction of more than 100,000 buildings. Hundreds of thousands of people were left homeless. More than 6,000 lives were lost. During the Kobe earthquake, traditional wooden homes collapsed under the weight of heavily tiled roofs. The newer, concrete structures that had been built to be earthquake resistant were better able to withstand the event. Although Japan's seismic design standards for highway bridges were updated in 1990, the Kobe earthquake resulted in calls for another revision, which was completed in 2002.

Imagine one-half of your community without shelter and exposed to the dangers of unstable structures and severed utility lines. Then consider the economic loss—more than $147 billion, not including economic effects from fatalities, businesses interruption, and lost production. If an earthquake were to hit San Francisco with the same magnitude as the 1906 earthquake, the economic losses would exceed $400 billion. With respect to movement of all five faults in the Southern California region, economic losses would easily exceed $200 billion.

With the swelling number of disasters, both domestically and internationally, we must continue to work hard to prevent their effects beforehand, and not just respond

to them once they occur. Successful mitigation also ensures that we can save a great deal of money on responding and recovering from a disaster: A World Watch Institute study found that every dollar spent on disaster mitigation and preparedness saves seven dollars in disaster-related economic losses.

Public-Private Partnerships

Community participation is necessary to make mitigation work. A proven way to get communities involved in building codes, and with other mitigation projects, is through locally based initiatives. When I was at FEMA, we started Project Impact, a community-based, pre-disaster prevention initiative. Through Project Impact, FEMA worked with local organizations and the business community to facilitate public-private partnerships that recognized prevention as a long-term investment. Among the California cities involved in Project Impact were the City of Berkeley, the City of Oakland, Napa County, the City and County of Santa Barbara, the City and County of San Bernardino, and the Las Virgenes Malibu Council of Governments (which comprises the Southern California cities of Agoura Hills, Calabasas, Hidden Hills, Malibu and Westlake Village).

THE Berkeley Home Repair Program provided free seismic upgrades (structural and non-structural) to low-income seniors and disabled people. The Transfer Tax Rebate Program provided rebates of up to one-third of the transfer tax amount to be applied to earthquake upgrades on homes. Additionally, a Tool Lending Library was created whereby hand and power tools can be loaned for free to Berkeley residents along with basic instructional advice on home repairs and upgrading for seismic safety. According to the Association of Bay Area Governments, 38 percent of single-family homes in Berkeley have had seismic and fire safety improvements since the implementation of Project Impact. In San Bernardino County, county officials worked toward mitigating earthquake, flood, and wildfire damage to facilities, providing emergency training and special services to employees and rendering technical assistance, financial resources, and other in-kind services to other segments of their communities.

Project Impact brought together more than 250 high-risk communities and over 2,000 corporate partners to prepare for disasters rather than simply react to them. We gave each community the opportunity to assess its risks, then develop and implement a comprehensive plan for addressing those risks. Communities used their funding from FEMA to update building codes or retrofit existing buildings according to the codes, as in Freeport, New York, where building codes now require hurricane straps to make the community's houses more hurricane resistant.

FEMA's goal was to help the communities help themselves. The partnerships formed at the local level for preparedness and mitigation made citizens better informed and brought communities together to find solutions. Citizens endure the terrible devastation that disasters cause. With initiatives like Project Impact and other state- and locally-support seismic risk programs, they have the opportunity to learn, hands-on, how to minimize the potential destruction. Citizens can then feel empowered to make a difference.

Cities are now realizing the need to plan ahead in partnership with local businesses, which have been long overlooked in initial planning efforts as being a key asset in times of crisis. Many private sector organizations have equipment and cutting-edge technology that could be of great assistance following a major catastrophic event. It is imperative that we do not wait until after a disaster strikes to know how government and businesses can work together.

WITH the frequency and intensity of natural disasters growing, it is imperative for businesses and governments—including schools, universities, and hospitals—to be leaders in forming partnerships for

In the wake of the next disaster, when the water recedes or the smoke clears, can the city government keep working?

disaster and catastrophic preparedness. The Project Impact initiative continues to be a catalyst and model for public-private partnership efforts worldwide.

Strong Leadership

Disasters often create chaos and confusion, accompanied by a mismatch between the needs and resources available to both responders and citizens at large. All my years of experience in crisis management have shown me time and again that effective leadership makes all the difference. In quiet times, leadership can sometimes recede behind the smooth flow of predictable events. But when disaster hits, leadership must dominate. For me, effective leaders have three key attributes; vision, the courage to make tough decisions, and the ability to inspire others to unified action.

I feel a special connection to President Harry Truman. We were both raised in small towns by hard working, ethical parents; neither of us attended college; and both of us were elected county judge. History, of course, records significant difference that I did not serve in Congress or live in the White House. Yet I regard him as a role model for the extraordinary strength of character that empowered him to make tough decisions.

"Once a decision was made," said President Truman, "I did not worry about it afterward." Leadership means carrying and fostering a vision, and he seemed to relish this responsibility. The famous sign on his desk asserted "The buck stops here," and that was reflective of his qualities as a leader.

Personal and Community Education and Planning

I cannot overemphasize that disaster preparedness is for everyone—governments, business, communities, families and individuals. Disaster preparedness needs to be institutionalized in every citizen, community, business, schools and universities throughout the state. Everyone should be planning for the inevitable crisis to occur.

AT times it is difficult for people who have not been through a disaster to understand the devastation. If they did, there would be no question about preparing and planning to minimize the impact. One can do a lot in a small amount of time to prepare, and it is important to increase the number of individual citizens prepared to take care of themselves during first 72 hours—even up to the first five days—following a disaster. In Los Angeles County, there is a very effective citizen education, awareness, and preparedness campaign called the Emergency Survival Program (ESP). ESP is a campaign designed to increase emergency preparedness at home, in the community, at work and at school. In San Francisco, there is a similar campaign called "72 hours." These community-based public education initiatives are valuable tools not only to create awareness, but also to prepare us for an actual disaster event.

Going forward, we as a nation need to ensure that what happened during Hurricanes Katrina and Rita does not happen again. Hundreds of local businesses were forced to close their doors after Hurricane Katrina. In the wake of the next disaster, when the water recedes or the smoke clears, can the city government keep working? Can businesses get back up and running? Can individuals and families rebuild their lives after losing everything? If employees cannot report to work for an extended period of time, will they be able to work remotely? If these are important questions for the private sector, they are critical ones for ensuring the continuity of operations and government.

Business owners can designate alternative sites for operations so employees will know where to report, and plan for employees who can work from home. They can also make

agreements with banks to ensure they can make payroll. They can establish contingency plans, draft memorandums of understanding to address reimbursement and liability and build relationships before an event. These actions will help to further strengthen the ability of state and local governments and the business community to recover after the next major disaster.

SURGE capacity—the ability to access additional resources during an emergency—is a serious concern, especially when we consider the catastrophic impact of a major earthquake in the Los Angeles or San Francisco areas. Cities and hospitals have started working on surge capacity plans for hospitals, shelters, and schools. States must prepare their at-risk populations with emergency plans that are tested and enforced for assisted-living centers, nursing homes, and public housing. There should be plans in place to address disasters before, during, and after they have taken place.

In a mass casualty or catastrophic event, we must plan better on how we are going to handle the massive number of folks, especially at-risk or vulnerable populations (seniors, special-needs population, etc.), who will need medical care, shelter, and other assistance. And as we learned from Katrina and Rita, emergency housing sites should be located away from equally at-risk areas, preventing the double evacuation of New Orleans evacuees and, similarly, local Texans around Houston and Galveston.

Creating an inventory of available assets and establishing pre-event contracts is also a great way to prepare for catastrophic disasters. It has been reported that the private sector controls approximately 85 percent of the critical infrastructure in our nation. Because of this, the business community must be included with local and state emergency planning officials during the initial planning phases of preparedness. There must be a seat at the table for business, because too much is a stake not to enlist this valuable resource. By planning ahead, private groups can help a local or state government meet increased demand for basic supplies such as water, food, energy, and shelter.

TO be fully able to deal with disasters and emergencies, our local, state, and federal responders, emergency managers and political leadership need to be well informed and well trained. This can only be achieved by having a substantial training and exercise program. Emphasis needs to be placed on re-energizing and supporting emergency management training capabilities to ensure for all-hazard training and exercises, the facilitation and delivery of exercises and a more robust outreach to state agencies and local government.

Communication is a foundation for public safety. I am a firm supporter of enacting a national standard for interoperable communications, whereby agencies with different systems and equipment can still exchange information. We need both interoperable communications and reliable back-up communications for all cities, counties, and states. When I was in St. Bernard Parrish, Louisiana, in the aftermath of Hurricane Katrina, there was one working radio. When officials stood on the roof, they had a weak signal at best. We will not have effective response and recovery until we have fully interoperable communications.

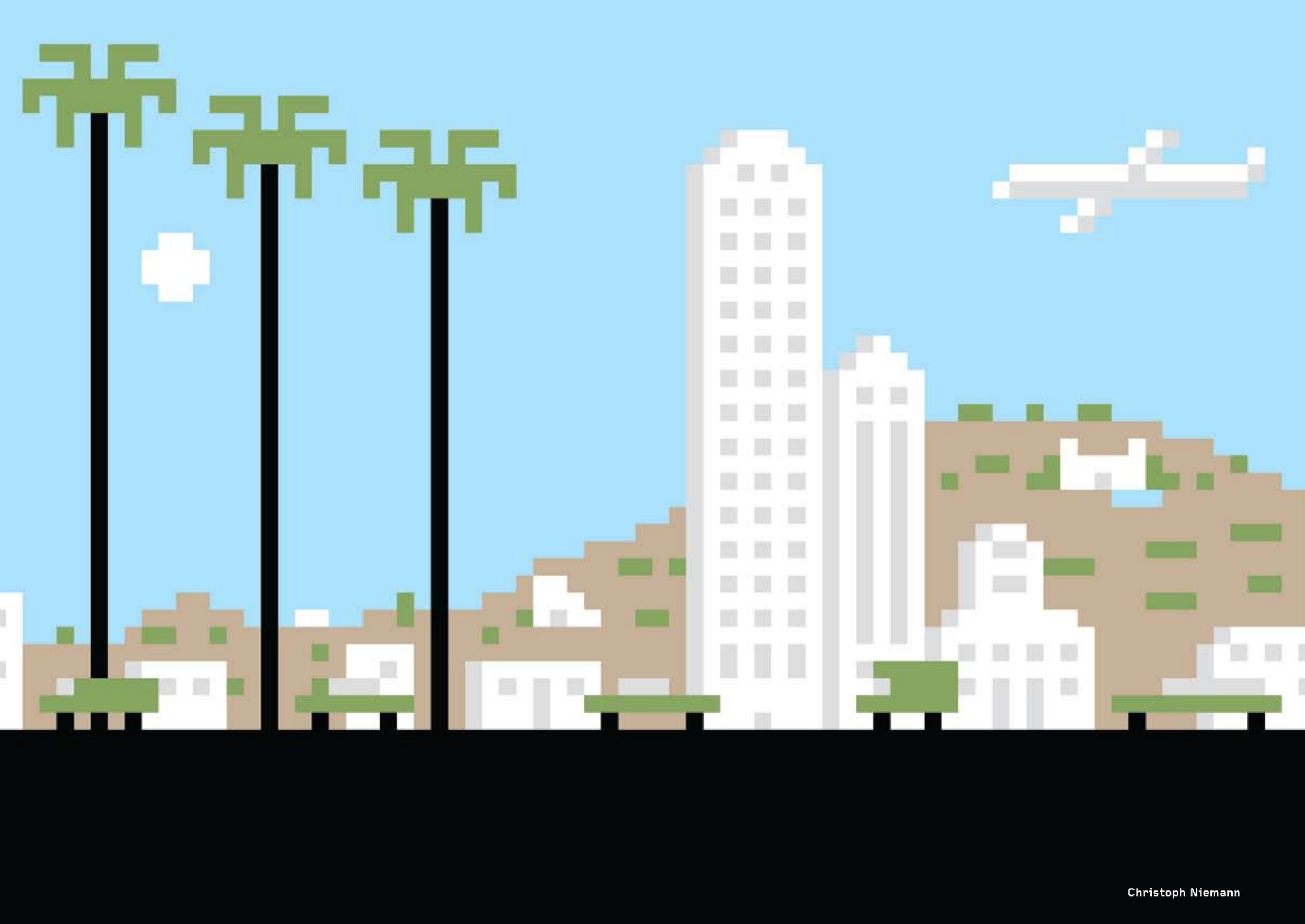
During my eight years as director of FEMA, we conducted all-hazards disaster response drills, training, and exercises with local and state government and response agencies every year. We built relationships among all those who are involved in response and recovery aspects in one way or another. Even if it wasn't a time of crisis, I would pick up the phone to ask if there is anything FEMA could do to help a state or local community better prepare itself and its citizens. This communication strategy builds the trust and camaraderie that are essential components of successful decision making during a time of crisis.

A spate of major catastrophes —including the South Asian tsunami in 2004, Hurricane Katrina in

2005, the Myanmar cyclone and the devastating earthquake in Sichuan, China, both in 2008—have once again demonstrated the awesome and destructive power of natural disasters. These mega-disasters were responsible for staggering loss of life: more than 200,000 killed by the tsunami; 73,000 from the Kashmir earthquake; more 1,200 in Hurricane Katrina. The Myanmar government estimates the cyclone's death toll will exceed 100,000; in China, nearly 70,000 people have been reported dead.

IF we recognize the importance of preparedness, and begin to do things differently, the model of cooperative, common sense prevention will save lives, secure jobs, protect our environment, and strengthen our communities for years to come. I believe that the same principles of prevention and partnership can work for any country or any community.

I also believe people work more efficiently through a balance of government leadership and community partnerships, rather than simply through government mandates. Because disaster preparedness, prevention and mitigation programs are successful only if the local community is committed to making them work, government agencies alone cannot make prevention an everyday activity. The people at the local level best understand their own needs, and they must have the resources to make improvements. Once we all understand why mitigation is so important, we will have the strength, individually and collectively, to make our communities safer.



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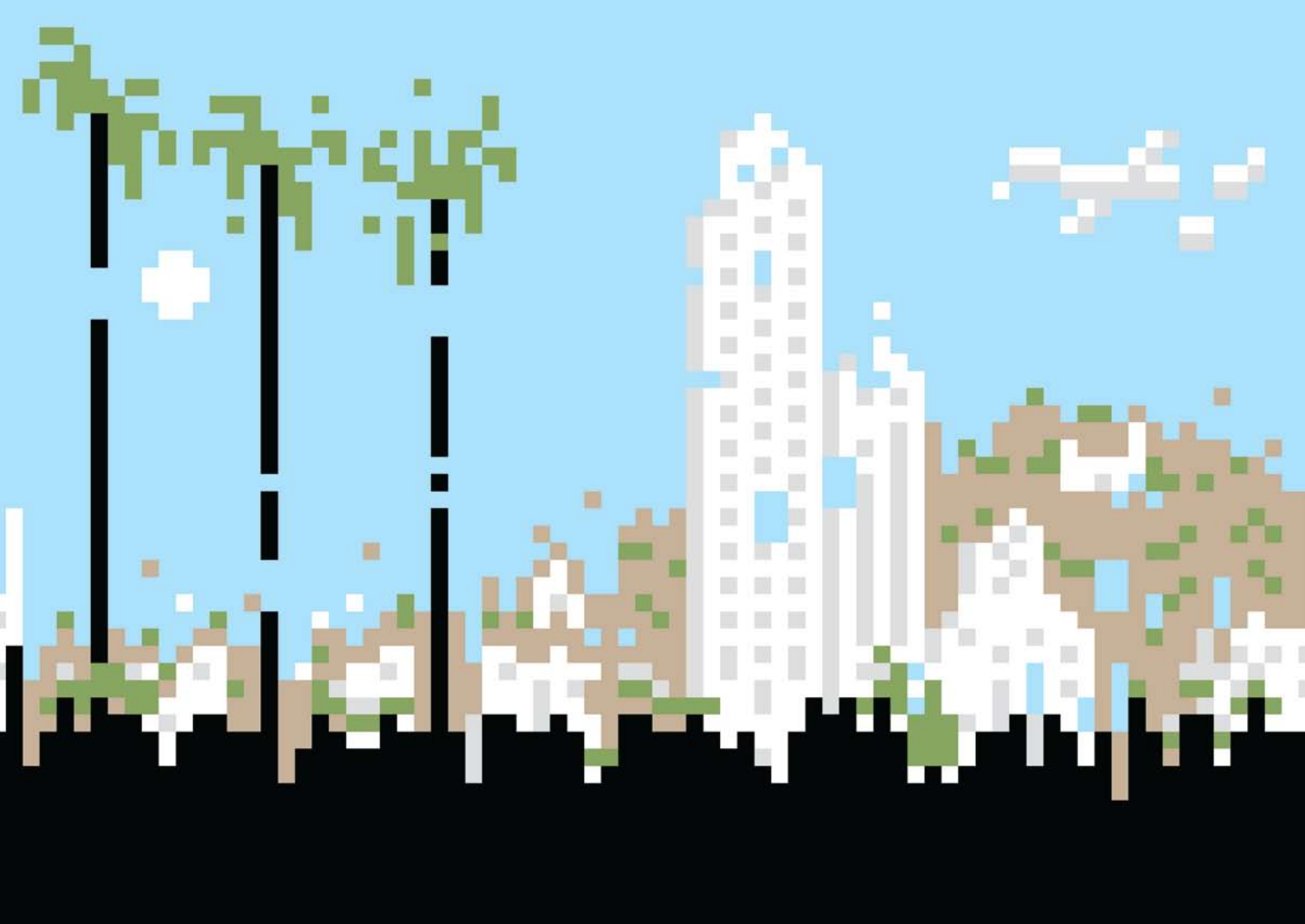
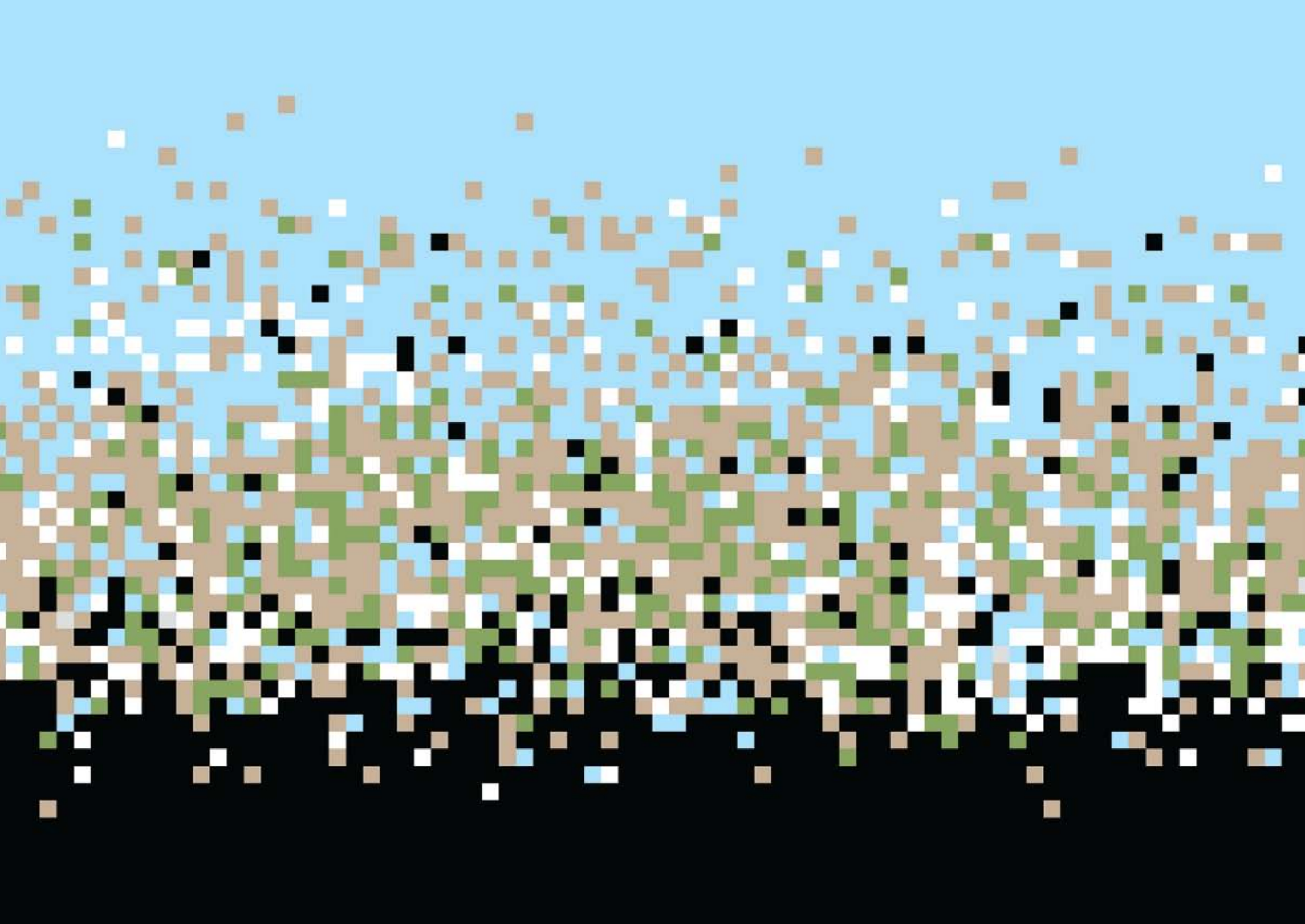
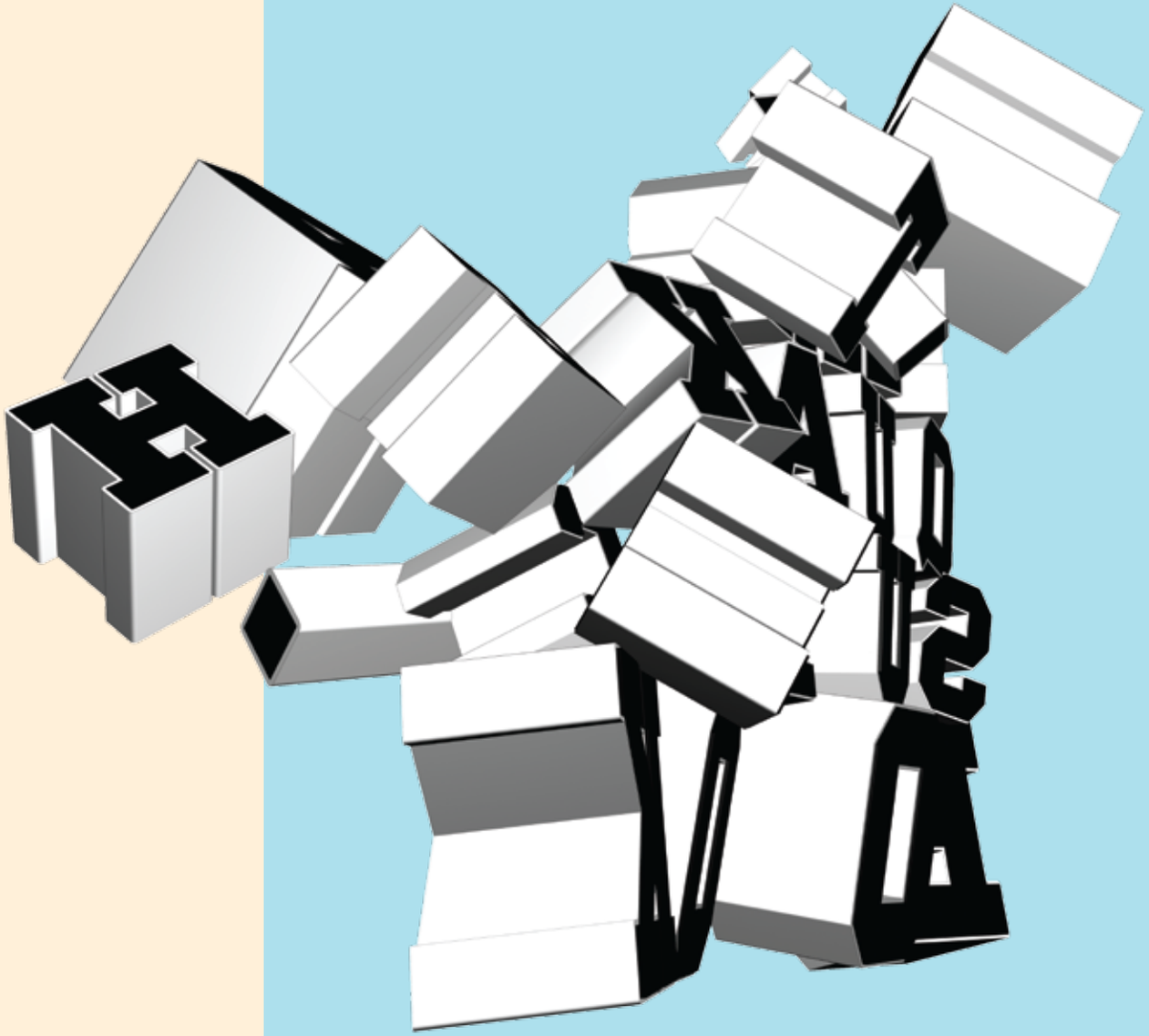




SECTION 4:
THE LONGEST SECOND:
THE EARTHQUAKE COMES



DON'T

stand in the door frame.

This advice, coming from the Southern California Earthquake Center's director of communications, Mark Benthien, distresses many lifelong Californians, most of whom were responsibly schooled from an early age that the place where the door cuts into the wall is the safest place to wait out an earthquake. "We no longer recommend that you stand in the door frame during an earthquake," he says. A door frame won't protect you from falling debris, it might fall over with the building you're in, and you probably won't be able to stand up anyway. The belief that a doorframe will protect you in an earthquake harks back to an earlier time in California construction codes, when often the only part of a house left standing after a quake was the frame that once held a door. Those houses were made of adobe, and we don't make houses in California out of plain adobe anymore.

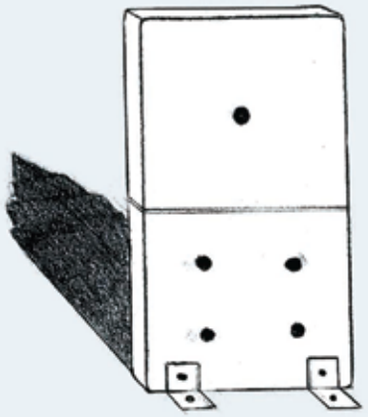
Instead, says Benthien, "drop, cover, and hold on. Pretty much anywhere you're at, that's the best thing to do. Drop to the ground before the earthquake drops you."

And start counting. Counting the number of seconds that pass will tell you how big the quake was, and how far it traveled along a given fault. It will also help you stay calm. (Six seconds of shaking is a magnitude 6.5; 20 seconds is a 7. A 7.8 magnitude earthquake will shake for the longest 50 seconds of your life.)

Three first-person accounts in this section describe what it's like to live through an earthquake: Poet David Hernandez writes of nature's reminder that we live here as we do anywhere, on "Her" terms. Lawrence Weschler gets a quick hands-on course in geology from the 1994 Northridge quake. And John Fante, in an excerpt from *Ask The Dust*, describes the terrible scene after the Long Beach temblor in 1933, and the crushing personal guilt that often follows what we still call "an act of God."

Kathleen Tierney of the National Hazards Center has devoted her life to understanding collective response to those events, and she weighs in here about her work, which includes evaluating human's mid-crisis priorities. Two professors from the John F. Kennedy School of Government, Arnold M. Howitt and Herman B. "Dutch" Leonard, detail the challenges of emergency response in extraordinary times. And Ellis M. Stanley, Sr., former General Manager of the City of Los Angeles Emergency Preparedness Department, talks to Aileen Farnan Antonier about spreading the word in a crisis.

Everett Ching



WHEN MOTHER NATURE VISITS SOUTHERN CALIFORNIA

David Hernandez

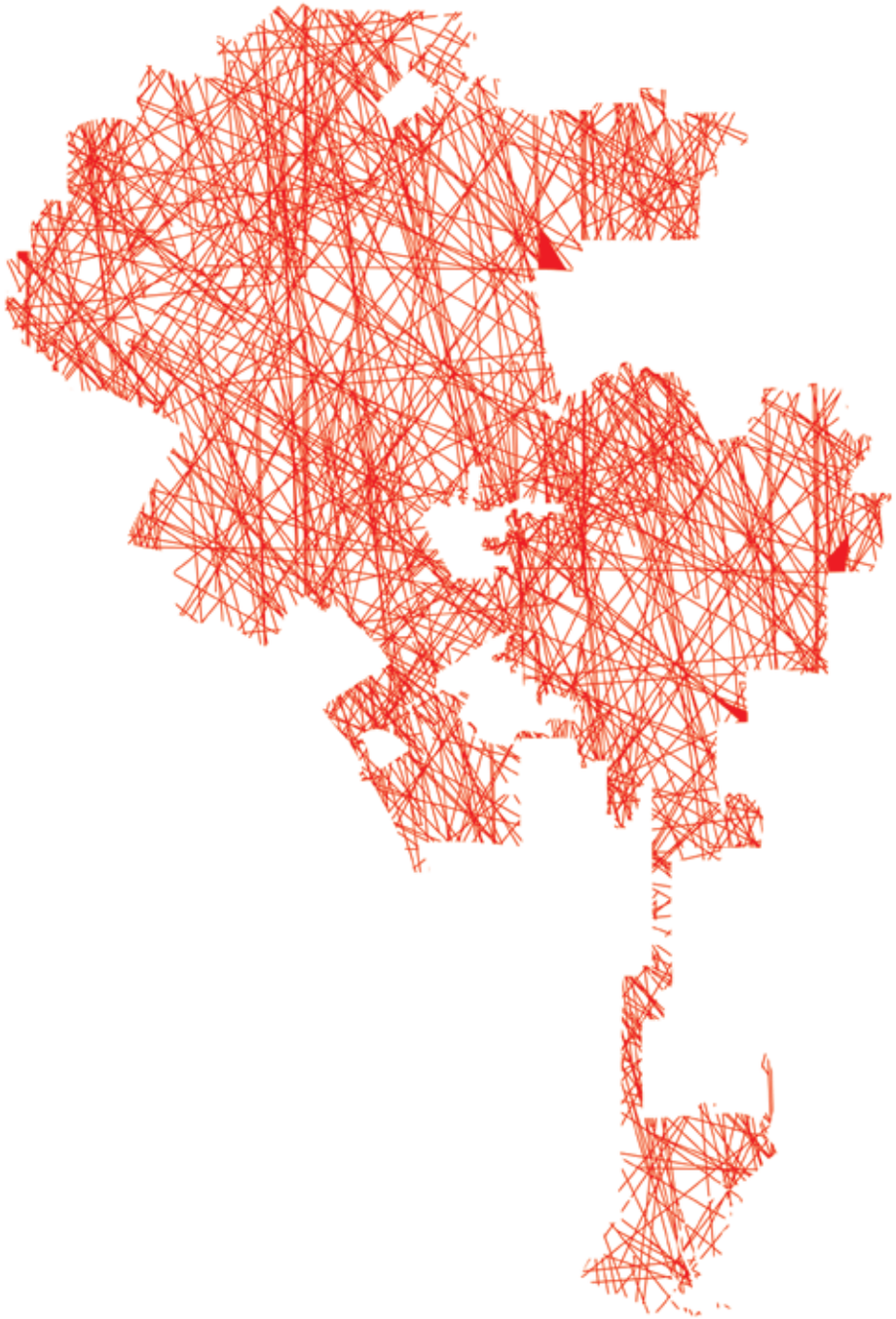
Katherine Siy

BEFORE we knew it the palm trees
were shaking like pompoms, seagulls
were pinned flat against buildings
like pressed flowers, and the billboards
down Sunset Boulevard took to the air
with the swiftness of a magician's card trick.

The wind's howling kept us up all night,
Imagine a blowdryer as big as a 747 engine
outside your front door. Imagine that sound
at three in the morning, windows rattling,
car alarms caterwauling in the distance.

Although the windstorm eventually dwindled
to a breeze, some of us knew She would return,
lugging stadium-size buckets of water, or wielding
a jackhammer with a blueprint of our fault lines
rolled under one of Her massive arms.

We surrounded our homes with sandbags.
We slept under doorframes and dinner tables.
We waited for Her to remind us
whose turf we were on.



Chieh Ni Chu

DISASTER RESEARCH: STUDYING COLLECTIVE BEHAVIOR

A profile of Kathleen Tierney by Aileen Farnan Antonier

KATHLEEN TIERNEY is director of the National Hazards Center, a clearinghouse for knowledge and information on natural disasters.

In a disaster, people's lives are disrupted indiscriminately, and the ways in which they cope with the resulting destruction and disorder are not governed by everyday rules and expectations.

MOST people consider themselves lucky when they are far removed from disaster; relieved to have been personally spared an experience like the 2004 Indian Ocean tsunami or Hurricane Katrina. Then there's a breed of person who chases tornados, flies into eyes of hurricanes…and wants to ride out an earthquake before its aftershocks subside.

Kathleen Tierney is such a person, and that's why she was happy to be on vacation in Puerto Vallarta, Mexico, when the Northridge earthquake struck on January 17, 1994. Only she among her fellow researchers at the Disaster Research Center (DRC) in the ice-bound Northeast was able to make it to the earthquake site within a few hours of the event.

"I turned on CNN that morning, saw the earthquake, went to the airport, and flew immediately to Los Angeles that day," says Tierney. "I was able to start a quick response study the first day, before I was joined by other DRC staffers a couple of days later."

Quick response research collects information on people's attitudes and actions that would be lost if it were not gathered immediately after a damaging event. Its aims are to understand circumstances and to document evidence that will not survive once cleanup and recovery begins. Just as engineers perform post-event reconnaissance to make improvements in structural engineering, social scientists use observation, interaction, and interviews to gain insight into the behavior of society, organizations, and individuals.

"My whole career has been bound up one way or another in disasters and disaster research," says Tierney, now a professor of sociology and director of the Natural Hazards Center (NHC) at the University of Colorado at Boulder. As an undergraduate student majoring in sociology, she got interested in the field of collective behavior, the study of social processes and events that do not reflect existing social structure but which emerge in a spontaneous way. Tierney was drawn to graduate study at Ohio State because E.L. Quarantelli, a renowned specialist in disaster research, and the Disaster Research Center—the first of its kind in the world, founded by Quarantelli—were there.

"I thought that disasters were an ideal context in which to pursue my interest in collective behavior," says Tierney. In a disaster, people's lives are disrupted indiscriminately, and the ways in which they cope with the resulting destruction and disorder are not governed by everyday rules and expectations. "The Disaster Research Center would give me the opportunity to travel, to do field work in other communities, and to be involved with major funded research."

After five years at the DRC, Tierney did her post-doctoral work in the sociology department at University of California, Los Angeles. "I began to get more and more involved in the area of earthquakes. Over the 10 years I spent in California—at UCLA, the University of Southern California, the California Seismic Safety Commission, and UC Irvine—a series of earthquakes happened in California, which gave me more research experience in doing community studies on the earthquake threat."

THREE weeks after Tierney's move to the East Coast in 1989 to assume the position of research director at the Disaster Research Center, which was now at the University of Delaware, Hurricane Hugo devastated the Southeast. Three weeks after that, Loma Prieta hit the San Francisco Bay area. It was a busy time in the disaster research business.

Tierney's work with earthquakes includes her participation in a study to obtain data on public perceptions of likely damage and disruption following an earthquake in the

San Francisco Bay area. "We discovered that people are very aware of the earthquake threat," Tierney says. "We also wanted to know whether they could attach importance to various elements in the built environment, such transportation networks, bridges, commercial buildings. We asked, 'What are the elements within your community that you insist must remain operational during an earthquake?' What came up were electrical power systems, water systems, and hospital and health care systems. Then we asked them about their willingness to pay to for programs to strengthen structures and lifelines. People showed their general willingness to pay for seismic improvements in the East Bay even if that meant they would have to pay more."

In 2003, Tierney moved to the National Hazards Center. The NHC primarily functions as a clearinghouse for knowledge on disasters. The center publishes a newsletter, the Natural Hazards Observer, six times a year, with a circulation of 15,000. The center organizes an annual workshop designed to bring members of the hazards research and applications communities together for face-to-face networking and discussion about current issues and trends that affect how society deals with hazards and disasters. The center maintains a library that houses a unique collection of social science literature and HazLit, a searchable online database that provides full access to the library's holdings. It also hosts Disaster Grads, an e-mail listserv for informal discussion and information sharing among undergraduate and graduate students who do research in the area of hazards and disasters.

NOW that she's director of the NHC, Tierney may not be able to drop everything and run to the next major earthquake site. Among her responsibilities is the administration of the center's Quick Response Program, a travel grant program for social and behavioral scientists who wish to go quickly to a disaster site to gather data that would otherwise be lost. After Hurricane Katrina, the program funded 26 different teams from universities all over the country. "So perhaps I would do field research myself or send my staff to do it," she says, "but I would also ensure that researchers who wanted quick response funds from us got them."

Chieh Ni Chu

Brenna Pribadi

Excerpt from

THE L.A. QUAKE

Lawrence Weschler

"THE WORLD SEEMS to hit you, to hit you hard, and then again, and then another time," writes author **Lawrence Weschler.** "And on top of all that there's the noise—a strange, curious noise, it takes a few moments to identify what it could possibly be—the sound of you screaming." **EXCERPTED FROM** an essay published in the *Threepenny Review,* Summer 1994, this first-hand account of the Northridge earthquake on January 17, 1994, comes as close as any to placing the reader in this strangest of moments, with all its peculiar sights and sounds.

WHEN last January's quake knocked a sleeping friend of mine right out of the bed in her Hollywood flatlands home, she stumbled through the dark to her shuttered living-room window and tweaked a crack open in the Venetian blinds, only to witness, at that very moment, a shooting star streaking across the sky. Subsequently she recalled for me how she was thereupon visited by two immediate thoughts, one riding fast upon the other: the first (deeply primordial), that this must indeed be the Apocalypse; the second (preternaturally rational), that if she was even capable of seeing the stars at all, well, then, the quake must have knocked out the electricity all over town. As, indeed, it had.

The quake knocked me out of a bed in a house on a Santa Monica hillside (I'd just arrived in town for a brief visit earlier that very evening), and as I stumbled outside, the cityscape spread out below me was inkblack in every direction—blacker than the sky—and eerily noisy: dogs baying, glass tinkling, car and burglar alarms wailing plaintively. All that, and underneath it all, some other sound, at first indecipherable: lulling, calming, pastoral... gurgling. A mountain stream, perhaps. And in fact a mountain stream, precisely: going out to the front yard I now realized that the underground reservoir which ordinarily supplies all of Santa Monica from the top of the hill must have sprung a leak, and the downsloping roadway had become a flowing watercourse.

NOISE actually, had been my primary experience of the quake itself a few moments earlier, even more so than the shaking—or rather maybe they were both the same. Everything was reverberation, as I came jolting to wakefulness—wildly various resonance—and my entire body one great throbbing ear. The noise is the sound of the earth itself wracking (the rockplates inside the ground crashing up against one another); it's the sound of the walls and joints throughout your house slamming; it's the sound of every unattached book and plate and couch and table in the house bouncing all about; it's the sound of your heart come leaping into your skull in sheer terror. Because then, too, there's the shoving: the world seems to hit you, to hit you hard, and then again, and then another time, really hard, and then once more. And on top of all that there's the noise—a strange, curious noise, it takes a few moments to identify what it could possibly be—the sound of you screaming.

OR anyway, that's how it all seemed to me. And I had it easy. As I say, I was on a hill, which is to say on the first floor of a house anchored in solid bedrock. For people down below, in the loose-soiled sedimentary flood plain, or else high atop skyscrapers, it was a whole lot scarier. Later that day I heard the story of a guy who was in town visiting from New York, staying with friends in their penthouse apartment, twenty stories up a tower nestled on the rim of the palisade overlooking the ocean. They'd lent him the best bed in the house—glass wall gazing out over the bay, mirrored walls on either side recapitulating the glorious view. He woke to the sound of an explosion, which was the glass wall bursting onto his lap. Luckily it was safety glass and it shattered into tiny jewel-like cubes, which presently buried him inches deep in his sheets. The building had begun swaying dramatically, as it was designed to do in such circumstances (better that it whip about like that than that it fracture): only, at that height, the sway was on the order of several yards in each direction. That torque in turn quickly compromised the perpendicularity of the walls, and the floor-to-ceiling mirrors began shattering convulsively. (They were not safety glass.) All of this in the pitch dark. The earth's shaking was by now communicating itself through to the top stories, and next, most horrifying of all, the building itself began shuddering in harmonic resonance. Those superfast vibrations in turn began to impel the bed, slowly but inexorably, toward the suddenly looming abyss. The quake only lasted fifteen seconds, which was lucky, because by the time it stopped, the

bed had already shimmied more than halfway across the room.

THE initial rupture in any earthquake might be likened to an atomic explosion—a sudden release of titanic amounts of energy at a single point which thereupon gets conveyed across space in the form of waves. But whereas in an atomic explosion the energy radiates out more or less evenly through atmosphere (much like the wavelets rippling out across the surface of a previously placid pond in the wake of a dropped pebble), with a quake, the waves are moving through earth of radically varying densities, slowing down or speeding up, expanding or constricting, depending on the consistency of the soils through which they pass. (Thus, my house on the rock face of the hill was less affected than those in the sandy flood plain down below.) More disconcertingly, the transition from one sort of surface to another often set off counter-reverberations: you get the initial wave moving one direction and a counterwave moving off of the face of the underground "wall" echoing back the other, redoubling the quake's intensity. In Santa Monica, waves that had traveled fifteen miles hit the edge of the palisade facing the ocean and then bounded back. (The damage in Santa Monica was most severe in the twenty blocks closest to the coast.) On any given street, the one wave might be at its crest while the counterwave was at its trough and they'd in effect cancel each other out: relatively calm sailing for those on the surface. But just a few streets over both waves could be cresting at the same place, and those people were in for quite a ride.

And in fact it wasn't just the intensity of the ground's shaking that determined the extent of the damage. As in the case of my friend in the penthouse, every structure has its own unique and inherent harmonic pitch, a frequency at which it will begin to vibrate on its own in response to any outside stimulus. (Think, for instance, about how you can get a champagne glass to start moaning merely by circling its rim with your wettened finger: too fast or too slow and the hum dissipates, but just right and the vibrations can get so strong as to shatter the glass.) Thus, ironically, some buildings (or freeway overpasses) may have been destroyed because the underlying ground vibrations were too slow. This, too, helps explain why one house might have buckled while its immediate neighbor emerged largely unscathed. It was a wonderfully educational week to be in L.A.

Vincent Hui

THE NOVELTY OF CRISES: HOW TO PREPARE FOR THE UNPRECEDENTED

Arnold M. Howitt & Herman B. "Dutch" Leonard

ARNOLD M. Howitt is executive director of the Taubman Center for State and Local Government at the John F. Kennedy School of Government, Harvard University. **Herman B. "Dutch" Leonard** is the Baker Professor of Public Management at the Kennedy School and the Snider Professor of Business Administration at Harvard Business School. Together they are faculty chairs of a Kennedy School executive education program Leadership in Crises and direct a research program on emergency preparedness and crisis management.

IN THIS ARTICLE*, Howitt and Leonard discuss the difficulties of preparing for unprecedented crises. While routine emergencies require enormous strength, the novelty of a crisis may call upon the creativity and improvisation of emergency responders to marshal personnel and supplies, reduce immediate dangers, and save lives.

The Core Challenges of Disaster Response

Recognizing Novelty and Effectively Improvising Necessary Responses.

In the course of their regular work, emergency responders ready themselves for a wide range of urgent circumstances. We call these "routine emergencies" not because they are in some sense "easy," but because the predictability of the general situation permits agencies to prepare in advance and apply lessons from prior experience. By contrast, "crises" differ from these more common (though possibly very severe) routine emergencies in having significant elements of novelty. The novel features may result from threats never before encountered: from a more familiar event occurring at an unprecedented scale, outstripping available resources; or from a confluence of forces, which, though not new, pose unique challenges in combination.

Careful preparation for routine emergencies constitutes an enormous source of strength. Responders don't need to size up the situation for an extended period, plan their response, assemble people and resources from scratch, or divide up roles and responsibilities before taking action. But in a crisis, the elements of novelty may invalidate predetermined emergency plans even though they may function quite well in dealing with routine emergencies. Badly damaged roadways, for example, could turn a highway evacuation route into an obstruction rather than a path away from disaster.

Compared with routine emergencies, therefore, crises require quite different capabilities. In crises, responders must first quickly diagnose any elements of novelty that may invalidate their expectations and prior plans. Then they need to improvise response measures adequate to cope with the unanticipated dimensions of the emergency. These measures, born of necessity, may be quite different from or exceed in scale anything responders have done before. Responders therefore need to be creative and extremely adaptable to improvise appropriate tactics, and rough implementation may have to be good enough.

Scalability and Surge Capacity.

In severe disasters, responders must quickly scale up operations to cope with far greater numbers of endangered people, more extensive damage, and a more extended emergency period than they usually face. If the crisis lasts for weeks, as one resulting from a major earthquake in Los Angeles undoubtedly would, responders will also have to cope with resource depletion and personnel exhaustion. But no local jurisdiction could bear the expense of stocking sufficient assets for a large-scale disaster that might never occur. What some see as a strategic reserve, others might regard as a waste of resources.

IF a major disaster strikes, it is virtually inevitable that affected jurisdictions will have to import and effectively absorb support from surrounding areas or—in very severe circumstances—from around the nation. Access to some resources can be arranged in advance, but the novel circumstances of a crisis may also generate unexpected demands. As

Hurricane Katrina revealed, it is far from a simple matter to mobilize and operationally deploy the right kind of resources in sufficient amounts and in a timely fashion.

Maintaining Situational Awareness.

In any crisis, responders (both individuals and organizations) must maintain "situational awareness." That is, they need to gather and assimilate key facts—often under conditions of great confusion, poor communication, and high uncertainty. As important as good intelligence is, however, robust situational awareness involves far more. Decision-makers must also be able to project the implications of the information they have gathered, so they can anticipate the likely consequences of a fluid situation. With anticipation comes at least some possibility of changing the future before it arrives. Projecting likely consequences also provides responders with a way of tracking what actually results against what they expected, thus providing a check on how well they understand what is truly unfolding. Finally, situational awareness involves being able to generate possible alternative courses of action and assess which hold the most promise of dealing with emergency conditions.

Integrated Execution in Real Time.

In a major disaster, as local agencies confront extraordinary operational demands, many emergency responders from outside the area are likely to converge on the scene. This will demand skillful coordination of aid workers, equipment, and organizations coming from different professions, agencies, jurisdictions, levels of government, and the public and private sectors—even though many of these people and organizations have had little or no prior experience working together.

IN the early 1990s, California established the Standardized Emergency Management System (SEMS), a flexible template for leading crisis operations that enables organizations to frame and rapidly implement response actions under enormous pressure. Congress has also recognized the need for such preparation, as reflected in the 2002 statutory requirement for a National Incident Management System (NIMS) that is compatible with SEMS. However, much work remains to develop skills in many jurisdictions that make limited use of these systems or in professional disciplines that have been unaware of or unenthusiastic about them. And as Hurricane Katrina revealed, the procedures to coordinate federal agencies with each other and with state and local responders are neither fully adequate nor effectively applied when required.

Operational vs. Political Leadership.

Widespread deployment and skillful use of NIMS is a necessary but not sufficient condition for integrated crisis response. The NIMS template has proved a highly effective technical system when goals are relatively unambiguous. By contrast, when goals are unclear or in conflict—when difficult, controversial tradeoffs must be made—NIMS lacks the political and moral authority to make the hard choices that present themselves. In the aftermath of a major Los Angeles earthquake, do response leaders—whether police commanders, fire chiefs, or public health directors—have the legitimacy to decide which areas should get resources and which should not? Do they have the community standing and ability to mobilize public support behind a difficult decision?

WE invest elected leaders with the authority to make key decisions about values and priorities for our society and to rally their communities behind their choices. But in a future emergency that cuts across organizational, jurisdictional, and level of government boundaries—particularly if government has been partially disabled by the crisis, as it was during and after Katrina—it may be unclear who has this authority and difficult to assemble them in the heat of the moment. The NIMS

model does not include an effective way to coordinate political leaders and operational commanders, especially when multiple jurisdictions are involved. The United States has not yet confronted this need, let alone fully thought it through and invented the emergency policy-making institutions it requires.

Handoffs Across Boundaries.

As action in a crisis scales up and becomes more complex, political leadership or specific responsibilities may need to be transferred from those initially in charge to others with different skills or broader authority and resources. Yet frequently, as observed in the Katrina response, this produces substantial friction. In the midst of crisis, political leaders may find it personally or politically difficult to recognize or acknowledge that exigent events surpass their ability to cope; they may, in fact, resist turning full or partial responsibility over to others better situated to deal with circumstances.

Addressing in advance the possibilities inherent in disaster scenarios can reduce the chances of hesitation or paralysis. It is not enough, however, for procedures to exist. Newly elected or appointed officials need to think through their personal preparedness—how well equipped they are to fulfill their substantive functions and moral responsibilities as crisis leaders. Institutionally, senior officials should address the conditions and procedures under which handoffs would be made, rather than addressing their obligations for the first time in the midst of catastrophe.

Improving Disaster Response

Addressing these core problems, particularly when the novel demands of a crisis must be met, means moving forward effectively in four realms: capabilities, structures and systems, people, and coordination.

Successful disaster response critically depends on adequate surge capacity: having sufficient equipment, supplies, transportation, and trained responders able to sustain themselves in the field for the necessary length of time. In the United States, the main challenge is not lack of resources but being able to locate, mobilize, and move resources swiftly—and to coordinate their use effectively upon arrival at a disaster scene.

Making the National Incident Management System truly operational at the local and state levels, as well as clarifying and effectively integrating it with the National Response Plan at the federal level is a critical step. It is also important to develop enhanced mutual aid agreements that authorize and make operational a wider range of cooperative arrangements between communities, states, and within regions for all emergency response functions.

BOTH first responders and emergency managers throughout the emergency response system have a general need for training and exercising. This training must be regular and varied, to keep skills sharp and to prepare new members of these professions for the threats they may encounter. In addition, there is a need to develop a cadre of senior disaster managers—in cities, states, and at the federal level—who develop proficiency and deep experience in managing emergencies.

As Katrina demonstrated, crises demand levels of coordination of governmental and non-governmental resources, including many that are not part of the normal configuration of emergency agencies. Coordination, moreover, has both a technical and political component—which necessitates construction of an infrastructure of coordination along both dimensions. The NIMS system is an important step in that direction, as is the deepening web of mutual aid agreements among jurisdictions. Yet both practice and relationships are crucial to the effective use of this infrastructure. It must be given life by being exercised regularly—through simulated and real action—and by building personal relationships among the people who will be involved when a real disaster strikes.

** This article draws on work previously published by the authors in the Fletcher Forum of World Affairs, Vol. 30:1, Winter 2006, pp. 215-221; and the Crisis/Response Journal, Vol. 2, No. 2 (June 2006), pp. 52-53, and No. 3 (September 2006), pp. 54-56.*

Kevin Wong

Excerpt from

ASK THE DUST

John Fante

I got up and plodded through the deep sand toward the boardwalk. It was the full ripeness of evening, with the sun a defiant red ball as it sank beyond the sea. There was something breathless about the sky, a strange tension. Far to the south sea gulls in a black mass roved the coast. I stopped to pour sand from my shoes, balanced on one leg as I leaned against a stone bench.

This is the Wrath of God

Suddenly, I felt a rumble, then a roar.

The stone bench fell away from me and thumped into the sand. I looked at the row of concessions: they were shaking and cracking. I looked beyond to the Long Beach skyline; the tall buildings were swaying. Under me the sand gave way; I staggered, found safer footing. It happened again.

It was an earthquake.

Now there were screams. Then dust. Then crumbling and roaring. I turned round and round in a circle. I had done this. I had done this. I stood with my mouth open, paralyzed, looking about me. I ran a few steps toward the sea. Then I ran back.

You did it, Arturo. This is the wrath of God. You did it.

Now the lamp posts were falling. Buildings cracked like crushed crackers. Screams, men shouting, women screaming.

The rumbling continued. Like a carpet over oil, the sea and land heaved. Dust rose. Somewhere I heard a booming of debris. I heard screams, and then a siren. People running out of doors. Great clouds of dust.

You did it, Arturo. Up in that room on that bed you did it.

Now the lamp posts were falling. Buildings cracked like crushed crackers. Screams, men shouting, women screaming. Hundreds of people rushing from buildings, hurrying out of danger. A woman lying on the sidewalk, beating it. A little boy crying. Glass splintering and shattering. Fire bells. Sirens. Horns. Madness.

Now the big shake was over. Now there were tremors. Deep in the earth the rumbling continued. Chimneys toppled, bricks fell and a grey dust settled over all. Still the temblors. Men and women running toward an empty lot away from buildings.

I hurried to the lot, an old women wept among the white faces. Two men carrying a body. An old dog, crawling on his belly, dragging his hind legs. Several bodies in the corner of the lot, beside a shed, blood-soaked sheets covering them. An ambulance. Two high school girls, arms locked, laughing. The building fronts were down. Beds hung from walls. Bathrooms were exposed. The street was piled with three feet of debris. Men were shouting orders. Each temblor brought more tumbling debris. They stepped aside, waited, then plunged in again...

IT was dark now. A few stars appeared. The temblors were ceaseless, coming every few seconds. A wind rose from the sea and it grew cold. People huddled in groups. From everywhere sirens sounded. Above, airplanes droned, and detachments of sailors and marines poured through the streets. Stretcher-bearers dashed into ruined buildings. Two ambulances backed toward the shed. I got up and walked away. The Red Cross had moved in. There was an emergency headquarters at one corner of the lot. They were handing out big tins of coffee. I stood in line, the man ahead of me was talking.

"It's worse in Los Angeles," he said. "Thousands dead."

Clifford Elbl

COMMUNICATION: THE WEAKEST LINK

A profile of Ellis M. Stanley, Sr.
by Aïleen Farnan Antonier

ELLIS M. STANLEY, SR. spent a decade working on emergency planning in the city of Los Angeles, and until 2007 was the general manager of the City of Los Angeles Emergency Preparedness Department. He is now director of western emergency management services for Dewberry LLC, a national planning, design, and management services firm, and assisted the city of Denver in coordinating the Democratic National Convention.

"WHEN I took this position in 1997, I was actually elated that I was coming to 'Disaster Central,'" says Ellis Stanley, general manager of the Emergency Preparedness Department of the City of Los Angeles. "I believed I was coming to a community that 'got it.' Everyone's well prepared—after all, they just had Northridge three years earlier. I thought, *Wow, I'm going to be able to come here and we're really going places.* Not the case."

Stanley rocks back in his chair in his office in City Hall. He looks capable and remarkably calm for a man who daily deals with the prospect of a disaster—pick one, any one-hitting the poorly equipped city and unprepared population. "We've got to change the culture here on every level. We have to have the vision and the political will at the very top, get the local jurisdictions to sign on, and get the people engaged."

Stanley came from Atlanta, where he was director of the Atlanta-Fulton County Emergency Management Agency. With over 30 years of experience, he is one of the earliest practitioners of this relatively young field. Stanley received his training in 1975 at what was then the only emergency management program in the country, the Defense Civil Preparedness Staff College in Battle Creek, Michigan. Today, over 125 colleges and universities have degrees in emergency management.

"The beauty of emergency management here in Los Angeles is that is we bring together all different disciplines and interests: geologists, engineers, architects, social scientists. I like the psychology of it, the social works aspect of it, and the hard science aspect of it. I like being able to get and synthesize information, so we can apply it with the public. It's a passion of mine, to help people and to get them excited about knowing how to coexist with the environment."

IN Southern California, coexisting with the environment means coming to terms with the prospect of the "Big One." And according to research by the U.S. Geological Survey and the Southern California Earthquake Center, the Big One doesn't even have to be that big: a earthquake of magnitude 7.2 to 7.5 on the Puente Hills Fault, which runs underneath downtown Los Angeles, could result in 3,000 to 18,000 fatalities; 56,000 to 268,000 injuries; and $250 billion in total damages. By comparison, the 6.7 Northridge quake resulted in 33 direct fatalities, 11,000 injuries, and $40 billion in damages.

"We recently had a couple of earthquakes that had tsunami warnings attached. I found out on CNN," Stanley says. "I shouldn't be finding that out on CNN."

"The perception is that Northridge was the Big One," Stanley says. "It was the biggest one anyone here had experienced, but Northridge was not the Big One for Southern California. We should be planning for the greater earthquake, not looking back at Northridge as being the benchmark for disaster. We spend too much time looking back instead of preparing."

If the Puente Hills scenario becomes a reality anytime soon, our ability to deal with it is uncertain. "On a given day we have a 25,000-bed capacity in all of Los Angeles County," Stanley says, "which may not be adequate for the number of injured. That's worsened by the fact that hospital collapses are possible because all the hospitals have not been retrofitted in accordance with the legislative requirements. The National Guard that we count on to operate mobile field hospitals is now in Iraq. Our major thoroughfares will probably be damaged, which will hamper mutual aid from other cities."

IN Stanley's opinion, the warning system is probably the weakest link in the emergency preparedness picture: it needs to be updated, streamlined, and standardized. For example, earthquake monitoring is the purview of the Department of the Interior and U.S. Geological Survey. When an earthquake fits the criteria of potentially generating a tsunami, the USGS has to issue a tsunami

warning—but tsunamis come under the Department of Commerce and the National Weather Service. The two tsunami warning stations are located in Alaska and Hawaii, and they use different terminology and technology for reporting their warnings. The result? "We recently had a couple of earthquakes that had tsunami warnings attached. I found out on CNN," Stanley says. "I shouldn't be finding that out on CNN."

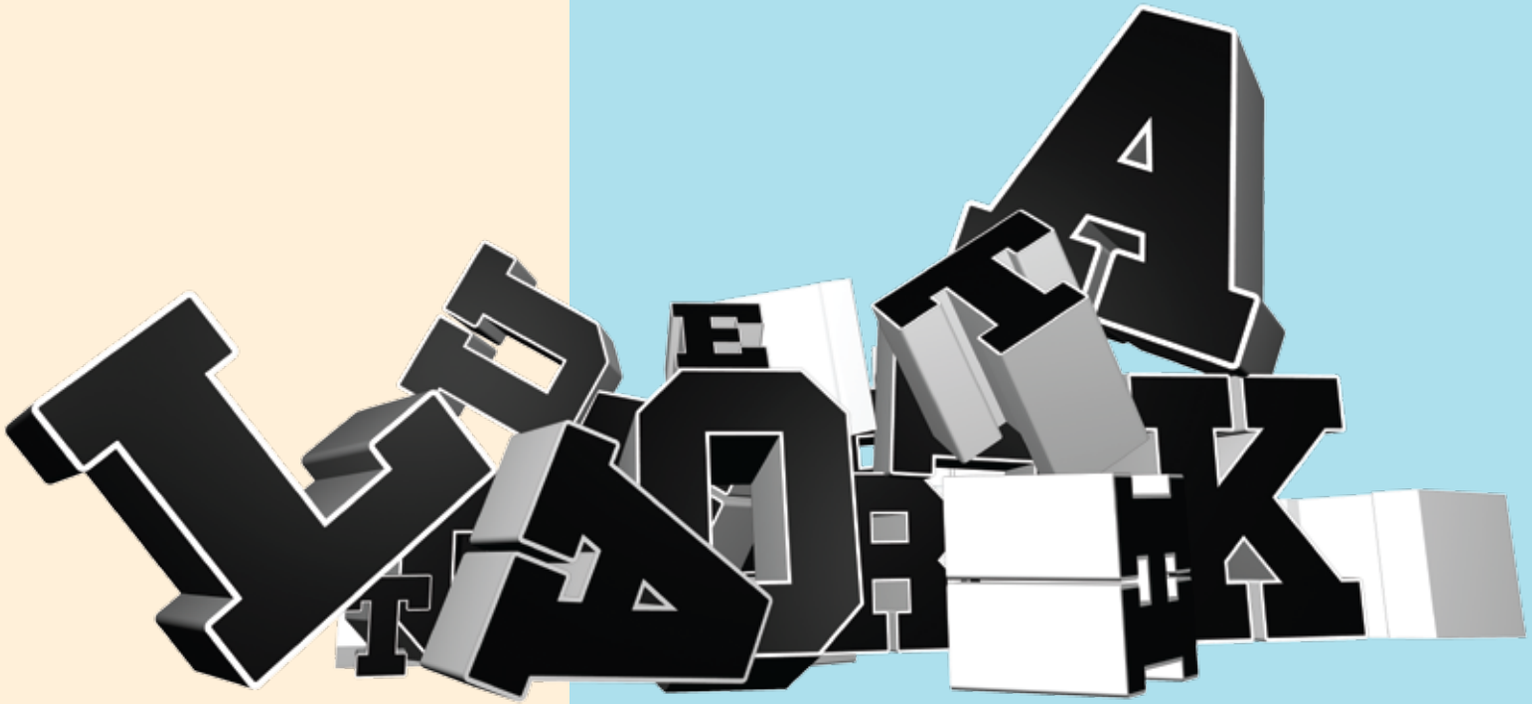
THE communications technology that can gather and dispatch information quickly and effectively certainly is available. "The technology is not an inhibitor anymore. The challenge is in our ability to take that technology and use it dynamically but seamlessly," Stanley says. "In an emergency, your podcast should be downloading, your cell phone ought to be going off, and your PDA ought to be going off. There should be something coming up on your computer. There's not one solution but multiple solutions that need to be coordinated."

For the ethnically diverse population of Los Angeles, preparedness information has to be distributed widely, in many forms and languages. The city is a diverse generational environment as well. "I was elated when I found text messaging and bulletins on MySpace.com helped rally 500,000 people to protest in the streets of L.A. against proposed immigration reform in March 2006," Stanley says. "I didn't know what MySpace was. That's not in my generation. You can't access it through the city—it's one of the sites they block. And it's one of the highest hit entities around. I called one of the senior VPs at MySpace to talk about how we might be able to use MySpace as a tool to reach out to young people."

Stanley acknowledges there's much confusion about what the preparedness message should be, and exactly what steps people should take. "We spend too much time and money branding the messenger, and not the message. The Red Cross might have five points of preparedness. The Centers for Disease Control might have 21 points of preparedness. The Department of Homeland Security may have a thousand points of light. Someone says prepare to be on your own for 72 hours. Somebody else says prepare for 48 hours. Another one says prepare for seven days. Guess what? The public doesn't prepare for anything."


LAW
BURNING MAN
WITHOUT
ECSTASY
KANYE
OR 50?
TORTURE
PORN

SECTION 5:
AFTERMATH: THE RESILIENT CITY ON A QUAKING PLANET



THE BANKS were grassy and covered with fragrant herbs and watercress. The water flowed afterwards in a deep channel toward the southwest. All the land that we saw this morning seemed admirable to us. We pitched camp near the water. This afternoon we felt new earthquakes, the continuation of which astonishes us.

—Fray Juan Crespi, chaplain and diarist for the Portola Expedition, soon after the Los Angeles River is named and crossed, August 3, 1769.

ACCORDING to Stanford geophysicist Amos Nur, the ancient city of Troy may have been destroyed—several times, actually—by an earthquake. It's a theory that makes some sense: The great mound city on the Aegean Sea lies close to the North Anatolian Fault, the same rift in the planet that crumbled the Turkish city of Izmit in 1999. By examining the remains of its successive civilizations, Nur has concluded that the damaged foundations and crushed skeletons are more consistent with seismic destruction than they are with the ravages of war. Nur also postulates that an earthquake inspired the biblical prophecy of earthly destruction: The city of Megiddo, Jordan, once known as Armageddon, lies astride an active fault.

Nur's theories are still new and controversial, but his ideas suggest a phenomenon that's unassailably true: Natural disasters can sometimes mean the end of cities, of communities, indeed of entire civilizations.

"The tells and mounds of the ancient world tell a story of urban settlements," writes Susan Hough in her own fascinating book, *After The Earth Quakes: Elastic Rebound on an Urban Planet*, "locations where in some cases cities were almost certainly destroyed by earthquakes." Without modern bulldozers, the ancient people who returned to these places—settlements strategically located near water or fertile soil—simply built their new cities on the mound of the old, unaware of the planetary forces that leveled great columns before them. "In what we call the earthquake belts of the world," Hough writes, "many of them cradles of civilizations, there are hundreds of mound cities."

WE sometimes flatter ourselves in the 21st century that we are immune to apocalypse. But our response to a magnitude 8 on the San Andreas Fault may determine the future of our communities. Will we come back and rebuild, or will our residents find refuge elsewhere?

In this final section of **The L.A. Earthquake Sourcebook**, scientists, sociologists, and experts investigate what brings cities back from disaster, and what does them in. Richard L. Bernknopf, an economist with the U.S. Geological Survey, and operations research analyst Anne M. Wein, describe how to plan for resiliency; Mark Ghilarducci, vice president of James Lee Witt Associates, reiterates in detail how all disasters are local. Architect and UC Berkeley Professor Mary Comerio explains the process of loss and financial recovery after an earthquake.

Reminiscences on past earthquakes by Arnold Genthe and Carolyn See enclose this section, as a reminder that disasters happen to actual people, no matter how detached and clean the studies around them might seem. David L. Ulin, author of *The Myth of Solid Ground: Earthquakes, Prediction and the Fault Line Between Reason and Faith*, contemplates the "culture of erasure," and wonders how living in a fault zone might have influenced how Californians think of their land, and their lives.

Finally, Anne Burdick and Sean Donahue, of the Graduate Media Design Department at Art Center, offer separate accounts of the primary considerations and carefully nuanced methodologies that went into shaping this *Sourcebook*, and the entire project.

Sung-Hae Baik

Excerpt from

AS I REMEMBER

Arnold Genthe

I have often wondered, thinking back, what it is in the mind of the individual that so often makes him feel himself immune to the disaster that may be going on all around him. So many whom I met during the day seemed completely unconscious that the fire which was spreading through the city was bound to overtake their own homes and possessions. I know that this was so with me. All morning and through the early afternoon I wandered from one end of the city to the other, taking pictures without a thought that my studio was in danger.

As I was passing the home of some friends on Van Ness Avenue, they were on the porch and called out, "Come in and have a drink." While we were raising our glasses, there occurred another shock. Everyone but my hostess and I ran outside. "Let us finish anyway," she said.

"Sure," I said, giving her as a toast the line from Horace, "And even if the whole world should collapse, he will stand fearless among the falling ruins."

On my way to the Bohemian Club I met Charles K. Field. "You dummy," he said. "What are you doing here? Don't you know that your house is going to be blown up?" It was the first time I had thought of such a possibility. Turning back I hurried up Sutter Street to find a militiaman guarding the entrance of my studio.

"You can't get in here," he said, handling his rifle in an unpleasant manner.

"But it's my home," I said.

"I don't care whether it is or not. Orders are to clear all houses in the block. If you don't do as I say, I shoot, see?"

There were rumors that some of the militia, drunk with liquor and power, had been shooting people. I did not want to argue with him, but I did want to get inside, with the hope that I might save a few of my things.

"How about a little drink?" I asked.

"WELL all right," he replied eagerly.

In my cellar I had been keeping a precious bottle—Johannisberger Schloss 1868, which I had brought from the Bremer Rathskeller in 1904—reserving it for a special occasion worthy of it. There had been several gay events that might have justified its consumption, but now there was no doubt about it. The special occasion had arrived. I knew that to my unwelcome guest it would mean nothing, so I brought out for him a bottle of whiskey and while he poured himself drink after drink, I sipped the wine, if not with the leisurely enjoyment that it called for, at last getting some of its exquisite flavor without having to gulp it down with barbarous haste.

When my militia friend had absorbed enough of his bottle, he pushed me through the door saying, "Now you have got to get out of here or I'll have to shoot you, see?" From a safe distance I watched with others the dynamiting of the block of our homes. There was no expression of despair. ("Well, there it goes!" "That's that!" being the only comments heard.) That night I slept in Golden Gate Park together with thousands of others who were in the same plight. The crowd there suggested more a camping out than refugees from a disaster in which they had lost their homes and all their material possessions. A cheerful spirit seemed to prevail throughout and whatever one had was gladly shared.

THE attitude of calmness of which I have spoken, the apparent indifference of the people who had lost everything, was perhaps not so much a proof of stoic philosophy that accepts whatever fate brings. I rather believe that the shock of the disaster had completely numbed our sensibilities. I know from my own experience that it was many weeks before I could feel sure that my mind reacted and functioned in a normal manner. If I had shown any sense, I might easily have saved some of the things I valued most—family papers, letters and photographs of my parents and brothers, books written by my closest relatives, and of course my more important negatives, which I could have carried away in a suitcase. As it was, practically everything I possessed had gone up in smoke.

Paul McCreery

THE SOCIAL CASCADE: PRESERVING COMMUNITIES AFTER A DISASTER

Judith Lewis with contributions by
Richard L. Bernknopf, Mark Ghilarducci,
and Anne M. Wein

IMAGINE that you're one of the lucky ones. You've come through the earthquake safely, and your house is still standing. You had stocked up on food to feed your family for a week. You have cash tucked away in a drawer, just for this emergency. There is gas in your car, batteries in your flashlights, water in your 55-gallon food-grade plastic drum. You're ready for life to start the drift back toward normalcy.

THE rest of your city, however, has fared less well, and as that week extends into a month, and then into three months, and then into a year—and still grocery stores and churches and schools stay shuttered—you begin to understand what community means. The neighbors who neglected to reinforce their houses in advance of the earthquake decide it now costs less to relocate than to return and undertake expensive repairs. Grocers and other retail stores board up for lack of business. Schools stay shut waiting for teachers to return, families stay away waiting for schools to reopen, and police, hospitals, and other public services limp along with a skeletal staff. Crime soars, supplies run scarce—ultimately, you decide to leave as well.

Until it played out so tragically in New Orleans' Lower Ninth Ward after Hurricane Katrina, this phenomenon—a cascade of crippling social disruptions that can impoverish, or in some cases obliterate, a community—had been little studied and only minimally understood. "Most disaster preparedness focuses on the first 72 hours after the event," says Richard L. Bernknopf, an economist with the U.S. Geological Survey who, with a team that includes operations research analyst Anne M. Wein, is currently studying the ways in which California cities can survive a large earthquake, not just structurally, but socially and economically. "In the first 72 hours, everybody's running around trying to make things work again," and trying to prevent the more tangible cascade of earthquake-related fires, landslides and other ground failures. "But if recovery efforts after a severe earthquake go too slowly over a significant period of time, the community could suffer permanent economic losses."

"Very few people have concentrated on looking at the implications of permanent change to a community in the wake of an extreme event," Bernknopf says. "What we're trying to understand is how to determine what a community needs in order to keep its social fabric intact." Bernknopf and Wein's research into the economic consequences of disaster recovery, part of the multi-hazards demonstration project led by Lucy Jones at the USGS, is in its early stages; the team is still figuring out how to model appropriate scenarios that raise relevant questions.

"Economic and other social consequences are challenging to predict," Wein says. "There's not an equivalent to engineering methods of predicting structural damage; the damage to a society and an economy is nonlinear, interconnected, and abstract compared to what happens to a building." Both stress that they have no evidence that Los Angeles will suffer post-disaster consequences anywhere close to what New Orleans suffered after Katrina. "Other parts of the [Gulf Coast] region that were affected as much, if not more [than New Orleans], are recovering more quickly," Bernknopf says. "Many experts consider Katrina a unique circumstance." Instead, post-Katrina New Orleans is one among many scenarios they're analyzing for clues to the economic consequences of what Wein calls "a potential natural hazard event" in Southern California. And once a model for that event has been determined, the next step is to engage California's citizens in the preparedness process.

"You can't just walk into a community and say 'Hello, what kind of risk would you tolerate?' You have to involve a lot of people in the discussion."

"We're usually talking about something with a low probability of occurring," Wein adds. "So part of

the challenge is to understand what a community considers acceptable risk. And because you can't just walk into a community and say 'Hello, what kind of risk would you tolerate?' You have to involve a lot of people in the discussion."

Those people include emergency responders, business owners, city planners, and nonprofit relief agencies. All of them operate with limited resources, and no one has the luxury of laying out a business continuity plan that will keep all operations up and running through any disaster.

"IF it's a 7.8 on the San Andreas, or a 6.5 on the Newport-Inglewood fault right under the city, obviously the damage will be widespread and extensive," Bernknopf says. "When you look at specific events, individuals and communities have to decide how to spend their money. And as the event gets larger it gets harder to decide how to spend your money."

"You can't protect everything," he says. "So the problems that we're interested in have to do with how people make tradeoffs when there are resources constraints."

Bernknopf and Wein are also examining the individual citizen's role in all this: what can the lay public reasonably do to bolster their community's ability to bounce back after a disaster? After coming to live in California following the Northridge earthquake in 1994, "earthquake insurance became so expensive and the deductible became so high that I didn't buy it," admits Bernknopf, who lives in earthquake-prone Los Altos. "Instead, I had my house retrofitted. For me, it was more cost effective to increase my self-protection than to purchase an insurance policy I wasn't sure would cover my loss." Because the resilience of a community after a disaster depends largely on how many structures remain habitable by humans, Bernknopf argues that it was a sufficiently responsible decision.

"It's an example of an individual's loss-reduction decision," he says, "in which more than one individual's well-being could be at stake."

"I think it all points to the familiar term that 'all disasters are local,'" says Mark Ghilarducci. The former Deputy Director of the California Governor's Office of Emergency Services, Ghilarducci is now vice president of the crisis and consequence management consulting firm run by former FEMA director James Lee Witt. "No matter what the federal government brings in or how the state responds," he says, "disasters are local events that affect people who live and work and participate in that community, and that's where disaster preparedness activities need to start and need to focus."

HE warns against what he calls the "9-1-1 syndrome"—the illusion that you can just dial a number and the authorities will always come running to fix things. "There's a false sense of security that our public protectors are always going to be there for us," he says. "But the federal government is not part of the local community and therefore generally not vested in the local community long term. When they're done responding and assisting, they leave—we've seen a lot of that.

"It's everybody's individual responsibility to protect their assets," he stresses, "to keep their business running, their employees safe, their structures standing—to be prepared."

ON the level of civic infrastructure, of course, there's only so much an individual—or even a group of individuals—can do. We can't, for instance, shore up our own freeway overpasses and reinforce our gas lines. But Ghilarducci says we owe it to our cities to know where the vulnerabilities exist, and pressure local authorities to fix them.

"People need to let their local governing councils and legislatures know that they have expectations. That's how change happens."

As a technical advisor and responder on the scene at hundreds of disasters over the last 25 years, Ghilarducci has seen what happens in cities where those vulnerabilities either weren't understood or addressed; he has witnessed the consequences of poor civic modeling, poor emergency planning and of a population

that failed to adequately consider the threats to its survival. "I was in Kobe, Japan, in 1995 during the earthquake that leveled the city," he says, "and saw a million square meters in a city the size of Oakland burn to the ground partly because the fire hydrant system they had in place was all underground." Firefighters had to first find and then lift this little cover and plug into hydrant systems in streets that were mostly buried in rubble.

THAT same year, Ghilarducci coordinated urban search and rescue operations in the aftermath of the bombing of the Alfred P. Murrah Federal Building in Oklahoma City; 10 years later, he served as an advisor to Louisiana Governor Kathleen Blanco following Hurricane Katrina. In every instance, the most daunting challenge was not luring financial and material support for response and recovery. It was knowing what to do with it once it arrived.

"In my opinion, we have not done nearly enough to address post-disaster commodity management," Ghilarducci says. "There's money for post-disaster reconstruction. You're seeing an outpouring of philanthropic support every time a disaster occurs. But money won't matter if you can't apply it to reconstruction and recovery efforts in an effective way.

"I've been at the scenes of disasters where people donate clothing, but then officials have no way to distribute any of it," he continues. "New Orleans after Hurricane Katrina was a good example: They had international donations of money, food, clothing, everything. But they didn't have a process to utilize it well. Millions of tons of commodities were pouring in—but they were pouring in for people who had left. What do you do with food and clothing in a community that's been completely wiped out?"

Ghilarducci envisions a partnership of nonprofit and non-governmental organizations such as Habitat for Humanity working in concert with business leaders and government agencies to restore public services to levels that allow most residents to stay or return. But he places the greatest responsibility on the lay public itself.

"I have seen in the worst-case scenarios that true long-term recovery begins with people in the community—people who prioritize what gets done first, second, and third and commit themselves to making those things happen. Whether that means senior citizen groups, churches, or the Lion's Club—those people become invested in the community through that process, and they get others invested in the community.

"And the people who are invested in the community," he says, "are the people who come back." ♂

Everett Ching

A PLACE TO LIVE AFTER THE SHAKING STOPS

Mary Comerio

MARY COMERIO is professor and chair, Department of Architecture at the University of California Berkeley; she is the author of *Disaster Hits Home: New Policy for Urban Housing Recovery.*

WHAT people think about disasters often depends on whether they have been in one. Most of us think hurricanes, tornadoes, floods and earthquakes are unfortunate events that happen to somebody else, somewhere else. Even in California, the heart of earthquake country, our transitory population does not seem to pay attention to the impending threat. But when a major earthquake happens, people will need to find alternatives to the things they normally take for granted—a place to live, a place to shop, a school, and a way to get to work (if there is a workplace remaining). Equally important will be the need for money to replace material losses, to find and rent a temporary apartment, to rebuild a damaged home.

After any disaster, shelter is an immediate and pressing problem, but after a major earthquake, finding a place to live can be a problem that lasts for years. In major earthquakes, housing losses account for 50 percent of the total value of the event-related losses and 95 percent of the damaged building stock.

At the time, the 1994 Northridge earthquake seemed like the largest disaster imaginable. A magnitude 6.7, it struck at 4:31 a.m. on January 17. With its epicenter in the San Fernando Valley, about 32 kilometers west-northwest of downtown Los Angeles, the earthquake was approximately the same size and in the same location as the 1971 San Fernando (Sylmar) earthquake. Northridge was much more damaging, however, because of the density of development that occurred in the ensuing 23 years.

Unfortunately, less than 15 percent of California homeowners carry earthquake insurance today.

While casualties were limited due to the early morning hour and the fact that it was a holiday, Northridge was the most destructive earthquake in the United States since the great San Francisco quake of 1906. The Northridge earthquake severely damaged buildings, particularly wood-frame homes, which comprised 50 percent of the overall estimated capital losses of $25.7 billion. With secondary economic impacts included, the total loss has been estimated at $40 billion. Eighty percent of the damage occurred in the San Fernando Valley, with the remainder spread throughout Los Angeles, Orange, and Ventura counties. The earthquake caused the collapse of seven freeway bridges and damaged 250 others.

SIX thousand commercial and industrial structures and 4,000 municipal buildings, schools, universities, and medical facilities were damaged. There were dramatic building failures in older concrete-frame buildings (the Kaiser Medical Building, the Northridge Fashion Mall and the parking garage at Cal State Northridge, for example). Less obvious, but equally important, was the failure of the welded connections in 100 steel-frame buildings.

Low rise, wood-frame construction sustained the greatest damage in the Northridge quake. There were 7,000 single-family homes, 5,000 mobile homes, and approximately 49,000 apartments that were destroyed or severely damaged. In total, almost 450,000 units (84 percent multifamily) were inspected and found to have some damage. The most common failure was the collapse of "soft first stories" in apartments and condominiums built over open ground-floor parking. There were 15 "ghost towns" created—neighborhoods where 90 percent of the housing units were damaged and rendered vacant. In the first months after the earthquake, inspections showed the majority of damage to be in multifamily housing, but three years after the event, when a full tally of insurance claims was available, it became clear that there was significant minor damage in about 300,000 single-family homes.

The Los Angeles region was in an economic recession at the time of the earthquake, and the multifamily housing vacancy rate was about nine percent. With undamaged units available, and an infusion of federal housing assistance, it was relatively

easy to re-house disaster victims, and most were placed in comparable units within their own zip codes within three to four weeks.

THE City of Los Angeles coordinated a successful effort to garner $321 million in Supplemental Disaster Relief Funds from the Department of Housing and Urban Development (HUD) to assist property owners whose requests for Small Business Administration (SBA) loans or Federal Emergency Management Agency (FEMA) grants were denied. In addition, the City worked directly with HUD officials on advance allocations of community development block grant funds targeted toward the acquisition and rehabilitation of damaged multifamily properties, loans to condominium associations, and special assistance to mobile home parks. While these special funds were targeted toward replacing low-income and multifamily units, the SBA loaned almost $2.5 billion to 99,000 homeowners. FEMA provided 120,000 individuals and families with temporary rental assistance, and gave $10,000 grants to 214,000 households.

AS of September 1996, the California Department of Insurance reported that there were 195,000 residential insurance claims. The average claim was $35,000 and the total paid was $7,808,000,000. The total of all paid claims was $12.5 billion. Research suggests that the actual value of residential losses was about 70 percent of paid claims. A number of factors contributed to the high payouts: 1) Companies underestimated the overall damage and quickly authorized payments. 2) Insurance rules, particularly the requirement to pay for finishes within the "line of sight" of the damage, increased claim values. 3) More than 80 percent of San Fernando Valley homeowners carried earthquake insurance and most made claims.

After the Northridge experience, insurance companies stopped offering earthquake polices as part of regular homeowner insurance, and the state created the California Earthquake Authority (CEA) to replace that coverage. Unfortunately, less than 15 percent of California homeowners carry earthquake insurance today. And the FEMA is no longer an independent and professionally managed agency, but a subsidiary of the Department of Homeland Security with a questionable record of performance.

WHEN Los Angeles is hit with another devastating earthquake, the situation could be considerably bleaker than after the Northridge event. Soft-story apartment buildings will fail. Lives and homes will be needlessly lost. Homeowners will not be able to afford repairs, without insurance and aggressive federal assistance.

The potential for another Katrina-scale disaster is immediate, yet difficult to fathom and easy to deny. There is no question that the traditional mechanisms for funding disaster recovery are wholly inadequate to meet the needs of an urban population. Almost two years after Hurricane Katrina, the failure of the federal response is still fresh and shocking. Even now, very few Katrina victims have a permanent place to live. Californians need to prepare, not only for the first 72 hours after the inevitable event, but for the task of recovery.

Kevin Wong

Reprint of

WHEN LIVING ON THE EDGE BECOMES A STARK-NAKED REALITY

Carolyn See

A PERSONAL REFLECTION after the 1987 magnitude 5.9 Whittier Narrows quake.

I was all the way outside, waiting for the house to slide down the cliff, within the first five seconds; that's traveling fast from the third floor. John Espey stayed fast in bed up here in Topanga Canyon, following the tradition of Gertrude Stein's uncle or dad, who, after sleeping through the Great San Francisco Quake, and on being awakened to hear the news, said something like "this will give us a bad name in the East," and then turned over and went back to sleep.

The truth is: Life is so boring so much of the time that most of the time we forget that we are all going to die. An earthquake reminds us of that in such a wonderfully gracing way.

My younger daughter lounged, stark naked and affable, in the doorway of her bedroom. She always thinks, at these times, of her elementary school teacher, a certain Mr. Russo, who so lovingly delineated his vision of doomsday—either by blast or by quake—that every fifth-grader left his class a gibbering doomsday idiot. Perfect training, it turned out, because every time the ground doesn't open up, it's very good news, and even as we pour coffee with trembling hands, we can take joy from how disappointed Mr. Russo must be, wherever he is today.

IT'S not the disaster, ever, but how we react. It's Jackie Kennedy bailing out of that convertible, or Cornelia Wallace throwing herself on top of her maimed husband. Good character has nothing to do with it; it's destiny, genes, chance, circumstance. A man on KNX radio confided after the quake that he'd just thrown up. And on KNBC television Kent Shocknek and Christopher Nance kept disappearing under their desks, even as they defended themselves from directorial chastisement that they were "panicking people."

The truth is: Life is so boring so much of the time that most of the time we forget that we are all going to die. An earthquake reminds us of that in such a wonderfully gracing way: We are here, only by the most marginal sufferance on the crust of the Earth—it shakes, you know, irritably, like a dog that has had it with those pesky fleas, and we're the fleas.

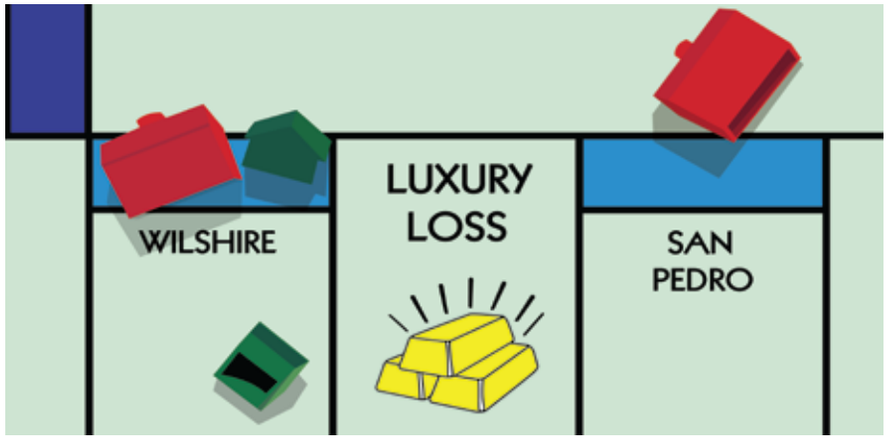
That's our human condition out here; that's our life on the edge.

There is something daring and wonderful about people who choose to live here, in the face of fire, flood, quake. This is extinction with panache and verve; hemispheres away from that stagnant gas that they had in Africa or the famines of Ethiopia and Bangladesh or the sad mudslide in Medellin. Here in Southern California we hang-glide through life—tempt the gods, joke with the gods, make friends with the gods. Every time we live through one of these, Mr. Russo once again is proved wrong, and we are once again alive.

After the San Francisco quake (a friend told us, at 8 a.m. Thursday in Topanga Canyon, jauntily smoking his seventh cigarette since the earth had given its petulant, coquettish puff), Native Americans were finally and completely convinced that white folks were nuts when they went back to rebuild their city: "After a warning like that!" Next door, at a macrobiotic learning center, a man in Levi cutoffs appeared at the top of his cliff. "Good Morning!" When we asked him if he felt the quake, he was cool. "A little roll or so. Sure woke me up, though!" Uh-huh.

SO then we go inside, and we watch Kent and Christopher dive under the desk. The phone begins to ring. The aftershocks have just started, and we scan the horizon for possible fires. Those boys on TV! I'd hate to be caught in an elevator with Kent (but then he'd probably feel the same about me). We talk about prisoners in jails, patients in hospitals, all of the places we'd rather not be...

Seventeen years ago my husband and I divorced. We were both young enough (comparatively speaking) to think that material things were not important. We ended up fighting only about a cat—a ceramic cat with flowers on it, bought in southern Mexico for $11. The fight was bitter. Two hours



Everett Ching

and 45 minutes after the quake, my ex-husband, remarried and back in the old house here in the canyon, calls up. We're all right over here; they're all right over there. His voice is exuberant. "You never know what you're going to do," he says. "I got up, stark naked, grabbed the cat, ran outside, and stubbed my toe."

I'm so glad to hear his voice! Glad his son and my daughters are fine! Glad he stubbed his toe! Glad he still honors that dumb ceramic cat! Glad to see that Kent Shocknek is reduced now to pointing to those overhead lights in the television station as his reason for diving under the desk. (Doesn't he remember those old moving pictures of W. C. Fields sauntering under lights during the Long Beach earthquake?)

"Stark naked" is where art, life and idealism meet during these quakes. We see what we are and how we act as we wait for the Big One. It's better to live on the edge, to be reminded, to crack jokes, to keep in touch, to know for sure that we're still alive.

Katherine Siy

SHAKEN, NOT STIRRED: EARTHQUAKES AND THE CULTURE OF ERASURE

David L. Ulin

WHAT is the meaning of earthquakes to Southern California? Not as physical, but as metaphysical events? How, in other words, does the physical landscape—its instability, it constant mutability—inform the culture that's been built here, the way people think about this place and, indeed, about themselves? This is a tricky question, for one of the truisms of Southern California life is that natives don't think about earthquakes—at least not in any lasting sense. But if earthquakes are a part of the landscape here, they are also a defining feature of the region's psyche—along with other natural catastrophes.

California, after all, is an elemental setting, a place where nature constantly asserts itself. Here, we don't so much master the natural world as we coexist uneasily with it, waiting for the next fire, flood, mudslide, drought, or earthquake to destabilize our lives. And yet, this uneasy coexistence manifests unexpectedly, in an elusive mix of denial and bravado, of fatalism and a devil-may-care optimism that is most notable for being almost frantically forward looking, more interested in the future than in the past. This is a region, after all, that is notoriously cavalier about its history, even as it exists in history's thrall. Does anyone remember the McNamara brothers, Caryl Chessman, the collapse of the San Francisquito Dam? No, in the phrase of social theorist Norman M. Klein, ours is a "history of forgetting," where more often than not, the past gets disregarded, overlooked.

What is the value of history in a place that could be wiped clean in an instant?

And yet, I think, there is a relationship between these two ideas—the forgetting and the elemental nature of the landscape, the elisions that define the psyche of the state. Partly, it's a matter of geography, of history: with all its seekers and transplants, California has always been "west of the west," in Mark Twain's famous phrase. Indeed, it's only in the 1840s, with the Mexican-American War and the Gold Rush, that California enters the vernacular of America, as a golden land, "America's Mediterranean," in which, as Charles Dudley Warner once put it, "nature seems to work with a man, and not against him."

WITH the coming of the transcontinental railroad, and the subsequent development of a spur line to Southern California in the 1870s, this impression became more pronounced. The region's long history of hypes and booms began as early as the 1880s; by the early 1900s, it was, in the words of Carey McWilliams, "a circus without a tent." In his landmark 1946 study, *Southern California: An Island on the Land,* McWilliams underscores the illusory, even contradictory, nature of the process: "There was little in Southern California, in the way of tangible assets, to justify this boom. The agricultural resources of the region were virtually untapped and undeveloped. Little irrigation was practiced and suitable methods of soil cultivation had yet to be evolved. The ranchos were being broken up, but no one knew just what to do with the land." Nonetheless, the lure of the place had to do with the fact that "Southern California was then as remote from the rest of the country as a foreign land or island, and people will believe anything, as [Stewart Edward] White observed of the land, 'that is far enough away.'"

THE cliché, of course, is that California—and particularly Southern California—was a land of opportunity, where the mistakes of the past could be if not rectified then disregarded, rendered moot. Certainly, this was the posture of the tycoons who developed Los Angeles and its environs: Henry Huntington, with his streetcars and his palace in San Marino; William Mulholland, who ran the Metropolitan Water District like a private fiefdom; and the syndicate of leading citizens (including Huntington, E. H. Harriman and Harrison Gray Otis) who in 1904, equipped with secret knowledge of a plan to irrigate the arid San Fernando Valley with water from the Owens River, bought up huge swaths of the Valley at cheap prices, in a deal that ultimately yielded

profits of more than $100 million. The city they built was a modern one, streamlined and speed-obsessed, a landscape of light and celluloid built on stolen water and expansive freeways, with no real understanding of —or regard for—the past.

Of course, it's easy to hang the psyche of Southern California on the tycoons, to suggest that their peculiar form of economic manifest destiny is responsible for making the region what it is. But these civic leaders were only the most prominent purveyors of an entire cultural identity, the idea that this was a place where we could live as we saw fit, unrestricted by either physical or emotional limitations of any kind. Look at population figures for Southern California over the course of the twentieth century and you can see the result of such a myth writ large. Vast migrations are part of the state's culture, of its heritage—and nowhere more than in greater Los Angeles, where the desire to reinvent oneself, to live outside history was, in some ways, a primary appeal. Religious cults, Hollywood, the endless suburban sprawl—all were costumes people could step into, ready-made and in some fundamental way, disposable, much like Southern California was perceived to be. Buildings came and went, landmarks were uprooted—why be bound by the past in a land with its eye on nothing but the here and now?

FOR many, such modernity was an empty promise. "Dust and old buildings and old people sitting at windows," John Fante writes in his 1939 novel *Ask the Dust,* "old people tottering out of doors, old people moving painfully along the dark street. The old folk from Indiana and Iowa and Illinois, from Boston and Kansas City and Des Moines, they sold their homes and their stores, and they came here by train and by automobile to the land of sunshine, to die in the sun, with just enough money to live until the sun killed them, tore themselves out by the roots in their last days, deserted the smug prosperity of Kansas City and Chicago and Peoria to find a place in the sun." Yet even in the face of such expansive emptiness, the image of the city lingers as a place where history, personal or otherwise, becomes irrelevant in the face of an eternal present tense.

Among detractors of California—and particularly Los Angeles—this remains a central issue, a reason not to take the landscape seriously. And yet, in actuality, the opposite is true. There's a reason such a culture grew up in California, and it's not only distance. There's a reason people came here, that they became here; there's an influence of place. It takes a certain type of person to uproot, to move to a new territory, undefined and sprawling, to reconstruct their lives. It requires a mix of desperation and adventurism, which in many ways are still the defining cultural components of the place. Here, we come back to the instability of the landscape, the way uncertainty is seeded into everything. It adds an urgency to how we operate, which goes beyond seismic activity into the rawness of the land itself. This is the underside to California's Edenic fantasies, the idea that apocalypse is right at hand. To live here, Joan Didion has suggested, is "to accept, consciously or unconsciously, a deeply mechanistic view of human nature," in which we have no choice but to find a way to frame, or at least reckon with, the larger forces that may emerge at any moment to disrupt our lives.

THAT this has become part of the ethos of Southern California is not without its irony, since initially, it was the 1906 San Francisco earthquake that offered Californians such a creation myth, the moment when the contemporary ideal of the state began to emerge. Partly, that's because this was the first truly modern disaster, photographed and recorded by man-in-the-street technology, the subject of newsreels and re-enactments, a source of public spectacle. Yet even more, what lingers is the mythos of reconstruction, of disaster as a source of opportunity, which has become perhaps the most compelling metaphor of how California views itself. For San Francisco, this was embodied by the 1915 Pan-Pacific Exhibition, during which, nine years

after the earthquake, the newly redeveloped city put itself on display. In Southern California, it manifests in other ways, from the renovated Angel Stadium in Anaheim, in which damage from the 1994 Northridge earthquake was literally redesigned out of existence, to a community like Malibu, which burns and is rebuilt with the regularity of the tides. "Malibu," Mike Davis writes in *Ecology of Fear: Los Angeles and the Imagination of Disaster,* "is the wildfire capital of North America and, possibly, the world." And yet, "wealthy Malibu homeowners benefited … from an extraordinary range of insurance, landuse, and disaster relief subsidies … [even though] as most experts will readily concede, periodic firestorms … are inevitable as long as residential development is tolerated in the fire ecology of the Santa Monicas."

Here, we have the full expression of erasure, of forgetting and reinvention, the idea that when nature wipes out homes or stadiums or cities, we can simply rebuild them—even as we know that the destruction will inevitably return. Such a way of thinking has become part of our psychology, the reason we knock down landmark structures in order to build generic (and entirely disposable) mini-malls, the reason we put our pasts, over very histories, aside to move ahead. This is the subterranean influence of disaster, of earthquakes: If you live in a place where the earth can erase everything in the tumult of an instant, why not do the same yourself? Yes, earthquakes are mirrors for our deepest trepidations—the Big One, the nightmare at the center of the future, the catastrophe every Californian knows is coming. (Coming? Overdue.) But more than that, they are emblematic, markers for the way we overcome.

FOR proof of that, let's look back at San Francisco, at the earthquake of 1906. On almost every level, it's an event that symbolizes our own odd interplay with history, the way we bend what happened into a metaphor of what we need. First, of course, there's the civic myth, which was perhaps the most pervasive story to emerge from the earthquake, the notion that the city was destroyed not by seismicity but by fire. Such an idea came into play immediately, part of an effort to soften the disaster, to redefine it as less exotic, an event everyone might understand. In an editorial published two days after the temblor, the *Los Angeles Times* argued that "all the earthquakes that had been experienced on the Pacific Coast, up to the time of the San Francisco disaster, caused less loss of life and property than an ordinary tornado or 'cyclone' causes in the Middle West." A parallel narrative, meanwhile, presented San Francisco as a phoenix rising from the ashes—the very symbol, coincidentally, on the city's seal.

FROM the perspective of history, it's easy to be cynical, and certainly these interpretations were managed manipulations, constructed by San Francisco's business and political leaders, who worried about investment, money, capital. At the same time, they suggest another set of connections, a way of thinking about California that gets at the essence of how we live. It's not quite denial, but more a studied indifference, a posture of taking things as they come. "The particular story that San Francisco told itself about the earthquake and fire," Wyatt notes, "was of a city coolly eyeing its own destruction, a city acting 'casual,' as Kathryn Hulme describes a man blowing drifting char from his hands, 'casual when you knew he wasn't feeling so.'" If you extrapolate a bit, you can read that attitude into the psyche of a state that, facing mounting problems of infrastructure, population, immigration, and education, has consistently avoided taking the long view, from Howard Jarvis' 1978 Proposition 13 campaign to the recall election of 2003.

In the end, it all comes back to the culture of erasure. What is the value of history in a place that could be wiped clean in an instant? How do we find meaning when the entire notion of meaning is rendered relative by the shifting landscape in which we live? The constancy of such questions—their appeal to California's boosters and detractors—has much to do with the legacy of catastrophe as

both physical and sociological event. To be sure, California has experienced plenty of earthquakes, from the protean upheavals of the 1800s (the San Francisco temblors of 1865 and 1868 and the 1857 Fort Tejon tremor, which remains, with an estimated magnitude of 7.8, Southern California's largest recorded quake) to more recent, and devastating, disasters like Loma Prieta and Northridge. The real issue, though, has less to do with the earthquakes than what we make of them. Yes, Los Angeles is heading for its own awful purging, as inevitable as the movement of the plates. Yes, we will have to find a way to deal with it, to rebuild the city and our lives. For all that, though, we are already priming ourselves for such an eventuality, by developing a culture where history is as malleable as the ground on which it is built. In such a landscape, what sustains us isn't so much where we've been or where we're going, but rather our own sense of living in the moment, the idea that this, too, shall pass.

Ahjung Baik

DESIGNING THE MESSAGE:

THE CHALLENGE OF THE L.A. EARTHQUAKE: GET READY PROJECT IN THE STUDIO

Anne Burdick

ANNE BURDICK is chair of the Graduate Media Design Program at Art Center College of Design. Most recently, she was lead designer and contributing writer for *The New Ecology of Things*, a transmedia book. Here she talks about the motive of this *Sourcebook*, to put preparedness on our collective front burner.

IF the idea of media design is to facilitate communication in new and unique ways, then The Los Angeles Earthquake: Get Ready project is a perfect challenge for media designers to undertake. As often noted within these pages, a major problem in achieving public preparedness for an earthquake that we all know is coming has been a lack of effective, memorable communication. Many experts have found that the importance of being prepared is a fleeting concept to most Southern Californians, and to the media that serve them. A quake occurs, and suddenly people are interested in what they should do to be ready the next time. But after a few weeks go by, the urgency and gravity of preparedness once again vanishes.

Therein lay the challenge for the design researchers in Art Center's Graduate Media Design Program: to put preparedness on our collective front burner, and help keep it there through the inevitable periods of seismic quiet. How we hope to succeed where traditional media strategies have thus far failed is through insight gained via our design-driven research methodology. The goal of this methodology is to understand people, and then to communicate with them in meaningful ways.

AS part of this research we will be looking at the tools of communication, both those available now and those envisioned for tomorrow. And whereas communication designers have historically crafted one-way messages—with interaction limited to reading, listening, or viewing—today, we are creating and anticipating communication tools that people can engage with which can help to make the information relevant to their lives. But whatever tools are used to convey the message of preparedness, the content has to be presented in a way that is going to connect and stick with the audience.

In order to develop a message that resonates, we conduct research using what we call "cultural probes." These are creative ways to extract the more ineffable feelings from the people we study—the things that never seem to come out of a straightforward question-and-answer approach. It's a methodology that values play, exploration, subjectivity, and uncertainty. For example, when we were researching attitudes toward the environment in the future, we gave the families in our study a set of globes that were painted white and a copy of *The New York Times*. We asked, If the earth could speak, what would it say? The collages created by the parents and the kids gave us the kind of raw material we're best at working with, which is visual material, rich with allusion and metaphor. The results allowed us to see the world through their eyes.

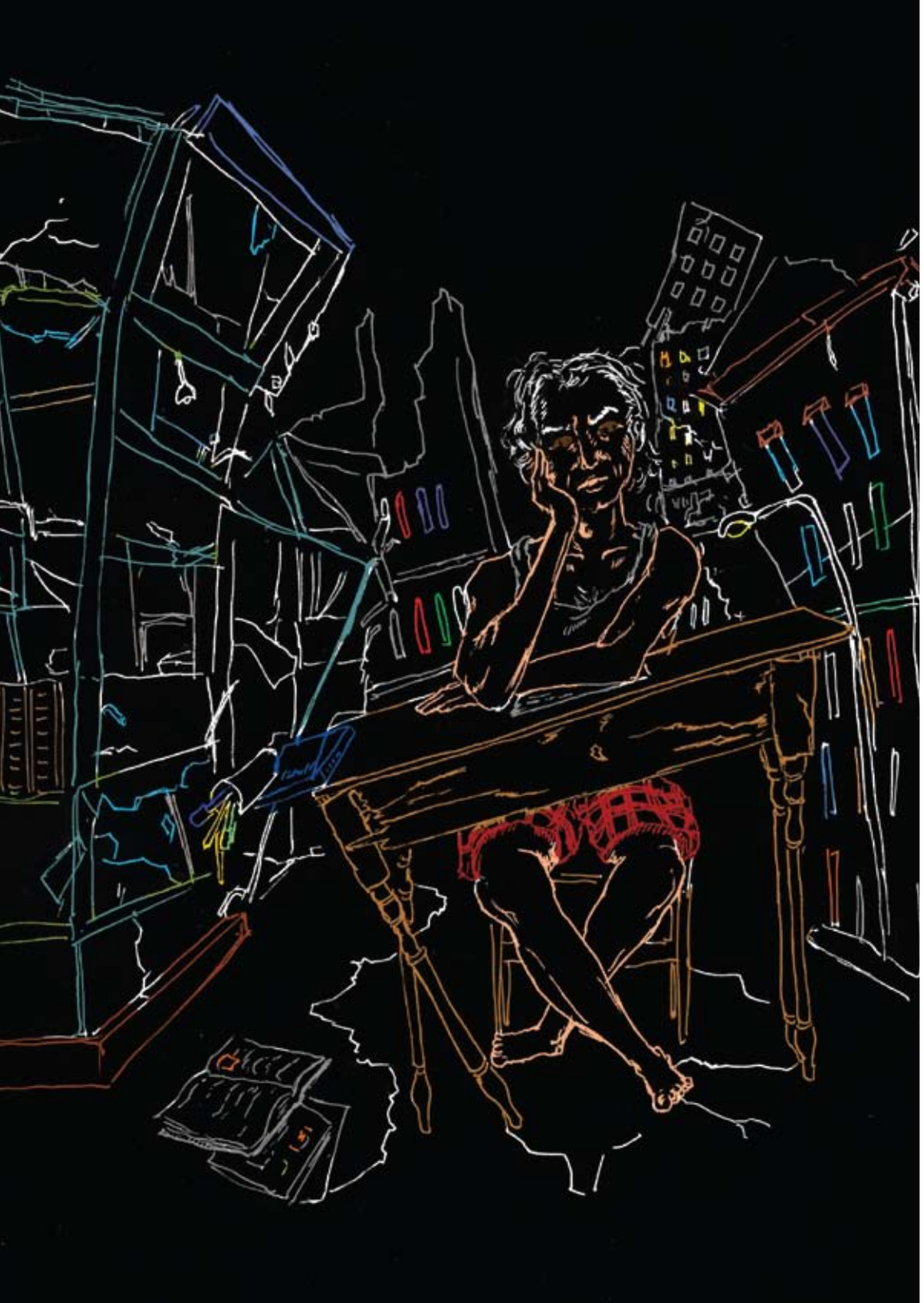
This human-centered research gives us an unguarded look into people's values. It is open-ended, and decidedly qualitative—as attested to by the many social scientists and psychologists who share our interest in this work. The method helps us figure out how we can best reach the people in our studies; how we can incorporate this important information into their habits and daily practices; how we can inspire and engage a population; and how we can ultimately change the kinds of conversations that take place around the dinner table. In this case, we hope those conversations will lead to real actions that help them to get and stay prepared for a major earthquake.

WITH insight into the habits, practices, and values of our study participants, we then set about finding the points within the larger communications landscape where all these things come together. These are the unique entry points, the unexpected ways of connecting with people in a form that they are really open to. There are so many communications forums now, with niche communities and an array of information flows, that tapping into those that already exist in order to disseminate our earthquake message would not only be economical, it might insure that the message is heard. Yet our knowledge and our thinking about future interactive technologies makes us look differently at what exists right now, so that we are in effect taking a new look at old media. We're constantly work-

ing to better understand how people engage with new forms of information, narratives, and entertainment.

WE believe that our unique approach will be key to the successful communication of earthquake preparedness information, and can help the residents of Southern California "get ready" for the big one, and for whatever comes after it.

Vincent Hui



Eric Lin

INTERVENTION DESIGN AND PREPAREDNESS

Sean Donahue

SEAN DONAHUE is the director of the Design Research program in the Department of Humanities and Design Sciences, and faculty member of the Media Design graduate program at Art Center College of Design. He is also the principal of ResearchCenteredDesign, a Los Angeles-based design practice. Here he describes the process and outcomes of his 2008 research studio.

CONSIDER your morning routine—a predictable commute, friendly greetings to and from the same people you see every day, your regular arrival at work or school. Now consider what might happen if you suddenly had someone else's routine—an unfamiliar commute, with new faces and greetings, and arrival at a different workplace. When everything changes, you are forced to gather new information on the fly, forced to immerse yourself in another world. And if you pay close attention, you can learn enough along the way to understand what makes this new world, and the people in it, tick.

In the winter of 2008, as part of The Los Angeles Earthquake: Get Ready project, I was asked to lead a studio in the Graduate Media Design Program at Art Center that would explore how a series of design interventions might increase earthquake preparedness for communities in the Los Angeles area. I was supported in this 16-week investigation by a group of four core designers: Yee Chan (Graduate Media Design), Vera Valentine (Graphic Design, undergraduate), Hye Rin Kang (Environmental Design, undergraduate), and Ken Huang (Graphic Design alumnus). As our work progressed and the need arose, we enlisted the expertise of participants ranging from carpenters and video editors to interpreters and emergency preparedness specialists.

Through our process of human-centered design research (see Burdick), we intended to gain insight into people's attitudes, perceived knowledge, and general community perceptions regarding the issues of earthquakes and preparedness. We would use this insight to design a responsive communication strategy that would foster behavior, attitudes, and individual and community activity that advanced preparedness efforts.

WE focused on the near-downtown district of Westlake. Being a densely populated, predominantly Latino community offering a range of social and cultural institutions and economic conditions, it provided an ideal opportunity to address the largest demographic in Los Angeles as well as issues associated with urban residential living and access to resources. We made it our responsibility to take preparedness guidelines, directives, and resources and instill them with the unique spirit of this diverse community in order to facilitate communication and incite action. To achieve this, we designed a multiphase, bottom-up strategy that could be used as a model for engaging this and other communities.

Sean Donahue

Phase 1: Introducing Ourselves.

To introduce our group and the topic of earthquake preparedness to the community, we conducted a large-scale design intervention in MacArthur Park, the social center of Westlake. The intervention event ran for a full day, during which we constructed 10-foot high letters and used them to spell five different words. Built one at a time with each left stand-

ing for 30 minutes, these words, in English and Spanish, were intended to reflect familiar earthquake rhetoric while piquing the curiosity of passers-by. Shake, Shift, Aware, *Alerta*, and *Alto* were used as prompts to generate interest and start conversation with park visitors, passing commuters, and local residents.

The physical construction of the letterforms was important to the intervention because it required community activity and teamwork. Before long, kids, families, and residents were participating in the construction. Once built, the words became a congregation space that invited people to rest, play, explore, or otherwise reside in the form. This outcome provided key opportunities for the interview team to make connections with the community. We invited people to share their perspectives with an on-site documentary crew, and were able to distribute information about specific resources to help prepare for and learn about earthquakes.

WE quickly learned that area residents were both interested in and knowledgeable about the subject, and discovered some of their unique concerns. They wanted to understand how to be prepared relative to their world—the unique space that constitutes their community, family, and neighborhood. Yes, they recognized the elements of our Red Cross preparedness kit—flashlight, kids toys, gloves, canned food, pocketknife, etc.—but the specific contents (the colors, shapes, brands, and language explaining the products) were not familiar to them. Because none of the specific contents looked like what one would see in a store in this community, the simple idea of where to buy such a key preparedness resource was not readily apparent to them—and, therefore, not something they were likely to follow up on. So we redesigned the kit, repurchasing everything in it from the local Dollar store. At that point, not only was the kit accessible, it was also familiar—and much more likely to stimulate an active response—because local residents shop where these crucial preparedness items are available every day.

Phase 2: Starting the Conversation.

This phase relied on the power of presence, so we rented a retail space across from MacArthur Park for two weeks and transformed it into a community dialogue center. The space was designed to provide an environment that facilitated dialogue and fostered communication among civic leaders, residents, and service providers, acting as a conduit to identify and directly address the unique preparedness issues of this community.

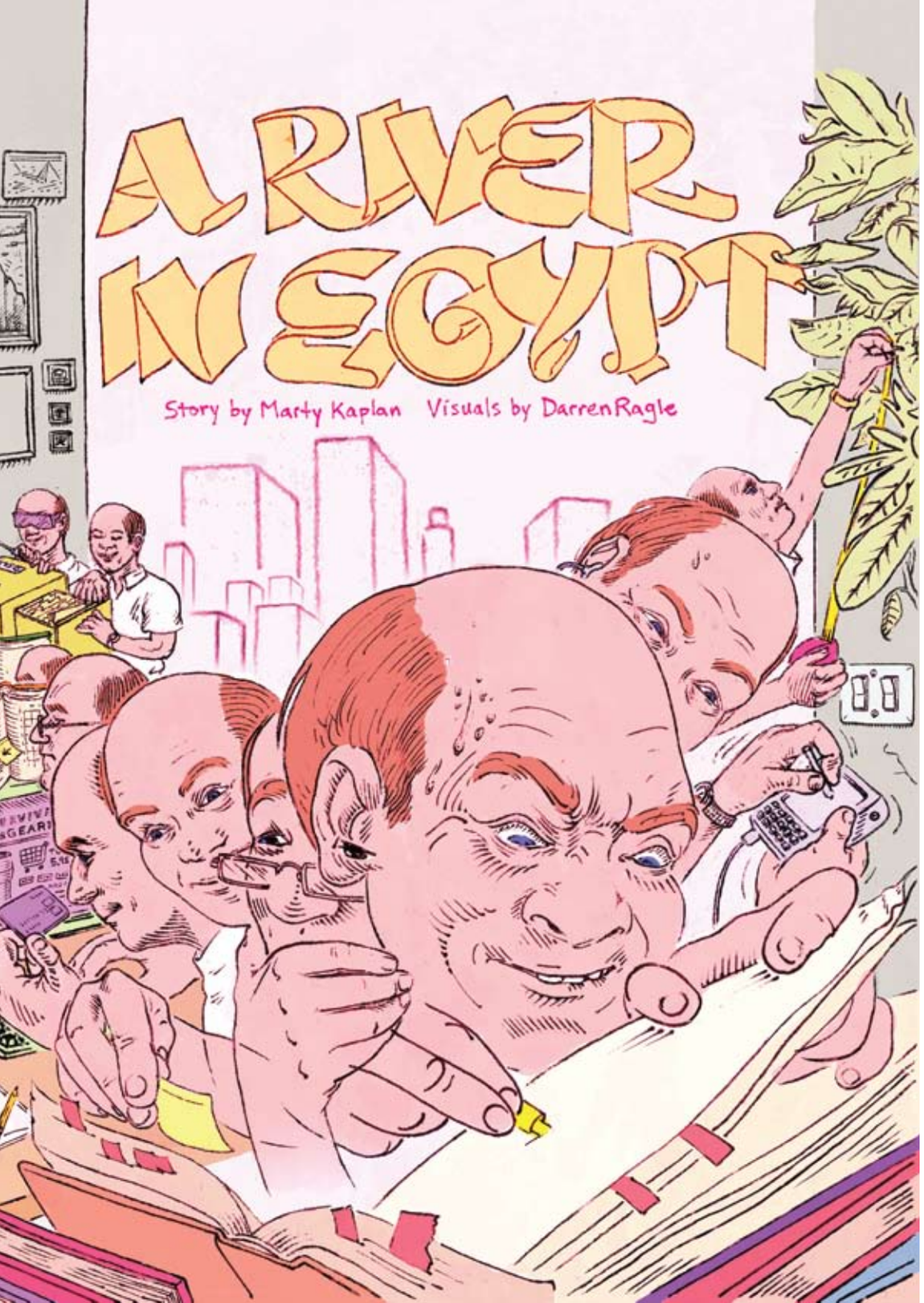
Our outreach initiative sought to get local community leaders and residents to take advantage of the dialogue center's resources. We held community meetings to share knowledge and create neighborhood-specific plans for addressing preparedness. We invited the director of MacArthur Park and representatives from the Los Angeles Department of Emergency Services to work through preparedness strategies that addressed the potential reality of scenarios in Westlake.

WE engaged with the populace, conducting interviews and hosting events, such as open forums and daily luncheons. Besides city and community emergency management officials, guests included representatives from the Coalition for Humane Immigrant Rights in Los Angeles, the *Asociacion de Salvadorenos en Los Angeles,* Charles White Elementary, *Mission Lirio De Los Valles,* Los Angeles Pregnancy Services, L.A. County Office of Emergency Management, and the Institute for Urban Initiatives,

among others. To underscore our focus on real-world post-earthquake preparedness, food was provided much as it might be in the aftermath of an actual emergency: distributed in generic boxes, and served in a way that required the guests to interact (and share, in the event of shortages) with those around them. The removal of choice and of familiarity with the process of how to acquire one's meal was meant to reflect the confusion that many relief efforts confront.

OUR process allowed us to design an environment that facilitated conversation and simultaneously exposed problems or gaps in the community support system. When we learned that the community was more likely to turn to a cultural organization than to a governmental agency for support in an emergency, we also discovered that these organizations were often unprepared to provide such aid. For example, we met with a number of religious organizations that acknowledged they would be pillars of community support in a time of crisis, but also admitted that they were not prepared to provide something as basic as water in the event of a large scale or citywide emergency. We then designed a formula that helped them quantify the supplies they would need to keep on hand, in storage, for such an event.

BY immersing ourselves in the unique community of Westlake, and exposing residents to the realities they might experience in a post-earthquake relief scenario, we were able to address the resulting emotional and social impact of those experiences. Unlike the surveys and analysis of social scientists that often rely on more abstract information, our boots-on-the-ground approach allowed us to visualize and design nimble, organic strategies and solutions based on real human feelings and actions—the essence of human-centered design.



Darren Ragle

THE 7 STEPS TO EARTHQUAKE SAFETY

Dare To Prepare

EARTHQUAKE professionals, business and community leaders, emergency managers, and others have organized the Dare to Prepare campaign to raise earthquake awareness and encourage earthquake readiness in Southern California. The main message of the campaign is that if you "Secure Your Space" before our next big earthquake you can protect yourself, your family, and your property.

THE DARETOPREPARE.ORG Web site includes how-to instructions for how to secure your space, along with videos, animations, and other resources, including the popular Putting Down Roots in Earthquake Country handbook. The following "Seven Steps To Earthquake Safety" is from this handbook. The Web site includes additional information for each step. Marty Kaplan's "A River in Egypt," in collaboration with illustrator Darren Ragle, is conceived in the genre of a graphic novel, and provides Marty's personal take on the challenge of preparedness.

1.
IDENTIFY POTENTIAL HAZARDS IN YOUR HOME AND BEGIN TO FIX THEM

Earthquake safety is more than minimizing damage to buildings. We must also secure the contents of our buildings to reduce the risk to our lives and our pocketbooks.

Several people died and thousands were injured in the Northridge earthquake because of unsecured building contents such as toppling bookcases. Many billions of dollars were lost due to this type of damage. Much of this damage and injury could have been prevented in advance through simple actions to secure buildings and contents.

You should secure anything:

1) heavy enough to hurt you if it falls on you, or;
2) fragile and/or expensive enough to be a significant loss if it falls.

In addition to contents within your living space, also secure items in other areas, such as your garage, to reduce damage to vehicles or the likelihood of hazardous material spills.

There may be simple actions you can do right now that will protect you if an earthquake happens tomorrow. START NOW by moving furniture such as bookcases away from beds, sofas, or other places where people sit or sleep. Move heavy objects to lower shelves. Then begin to look for other items in your home that may be hazardous in an earthquake.

Additional information, including how-to instructions, is available at: www.daretoprepare.org

Some of the actions recommended on this page may take a bit longer to complete, but all are relatively simple. Most hardware stores and home centers now carry earthquake safety straps, fasteners, and adhesives.

In the kitchen:

Unsecured cabinet doors fly open during earthquakes, allowing glassware and dishes to crash to the floor. Many types of latches are available to prevent this: childproof latches, hook-and-eye latches, or positive catch latches designed for boats. Gas appliances should have flexible connectors to reduce the risk of fire. Secure refrigerators and other major appliances to walls using earthquake appliance straps.

Electronics:

Televisions, stereos, computers, microwaves, and other electronics are heavy and costly to replace. They can be secured with flexible nylon straps and buckles for easy removal and relocation.

Objects on open shelves and tabletops:

Collectibles, pottery objects, and lamps can become deadly projectiles. Use either hook-and-loop fasteners on the table and object, or non-damaging adhesives such as earthquake putty, clear quake gel, or microcrystalline wax to secure breakables in place. Move heavy items and breakables to lower shelves.

Hanging objects:

Mirrors, framed pictures, and other objects should be hung from closed hooks so that they can't bounce off the walls. Pictures and mirrors can also be secured at their corners with earthquake putty. Only soft art such as tapestries should be placed over beds or sofas.

Furniture:

Secure the tops of all top-heavy furniture, such as bookcases and file cabinets, to a wall. Be sure to anchor to the stud, and not just to the drywall.

Flexible fasteners such as nylon straps allow tall objects to sway without falling over, reducing the strain on the studs. Loose shelving can also be secured by applying earthquake putty on each corner bracket.

Water heater:

Unsecured water heaters often fall over, rupturing rigid water and gas connections. If your water heater does not have two straps around it that are screwed into the studs or masonry of the wall, then it is not properly braced. Bracing kits are available to make this process simple. Have a plumber install flexible (corrugated) copper water connectors, if not already done.

In the garage or utility room:

Items stored in garages and utility rooms can fall, causing injuries, damage, and hazardous spills or leaks. They can also block access to vehicles and exits. Move flammable or hazardous materials to lower shelves or the floor.

2. CREATE A DISASTER-PREPAREDNESS PLAN

Will everyone in your household do the right thing during the violent shaking of a major earthquake? Before the next earthquake, get together with your family or housemates to plan now what each person will do before, during, and after.

Once the earthquake is over, we will have to live with the risk of fire, the potential lack of utilities and basic services, and the certainty of aftershocks. By planning now, you will be ready. This plan will also be useful for other emergencies.

Plan NOW to be safe during an earthquake:

- Practice "drop, cover, and hold on." (See Step 5)
- Identify safe spots in every room, such as under sturdy desks and tables.
- Learn how to protect yourself no matter where you are when an earthquake strikes.

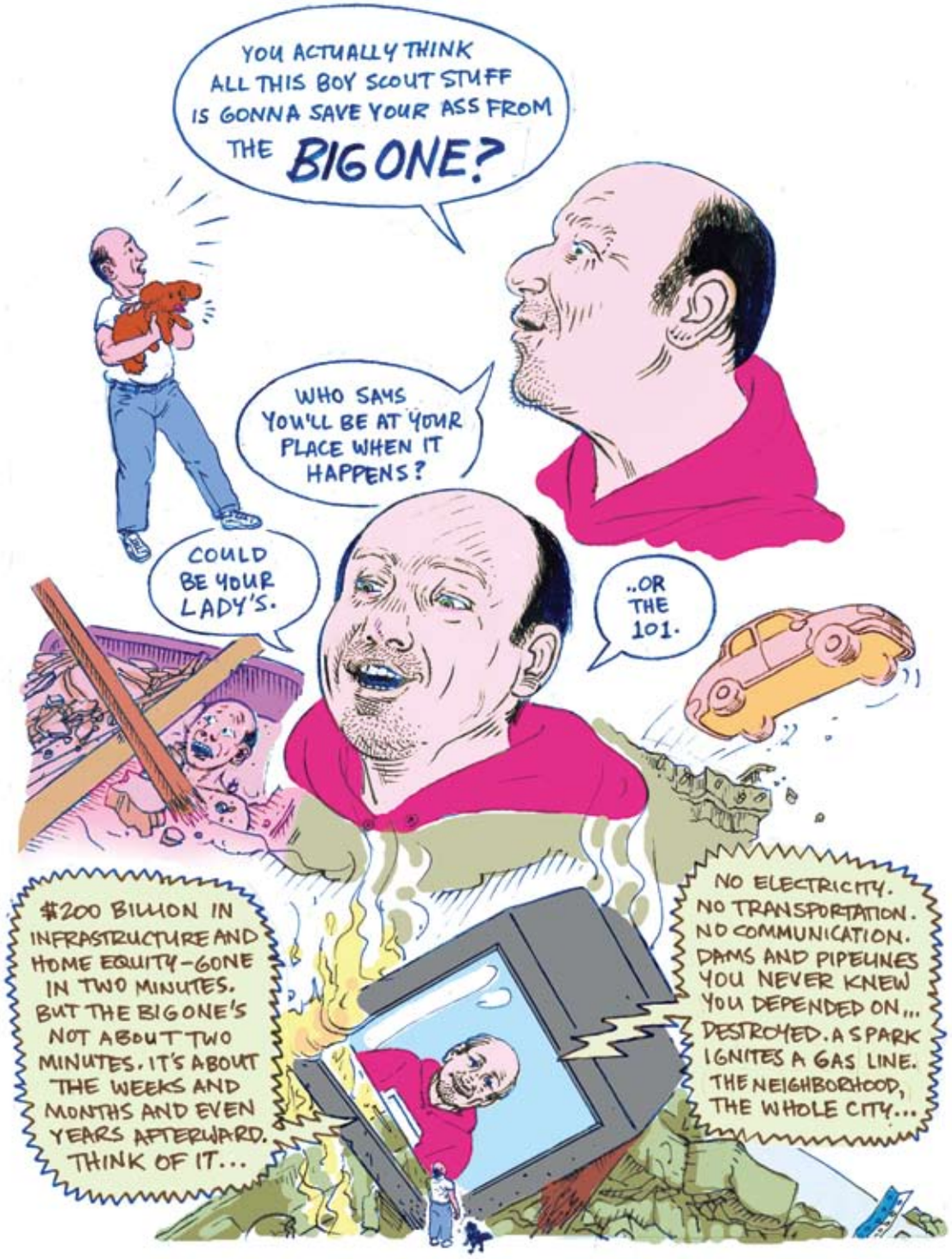
Plan NOW to respond after an earthquake:

- Keep shoes and a working flashlight next to each bed.
- Teach everyone in your house hold to use emergency whistles and/or to knock three times repeatedly if trapped. Rescuers searching collapsed buildings will be listening for sounds.
- Identify the needs of household members and neighbors with special requirements or situations, such as use of a wheelchair, walking aids, special diets, or medication.
- Take a Red Cross first aid and cardiopulmonary resuscitation (CPR) training course. Learn who else in your neighborhood is trained in first aid and CPR.
- Know the location of utility shut offs and keep needed tools nearby.
- Make sure you know how to turn off the gas, water, and electricity to your home. Only turn off the gas if you smell or hear leaking gas.
- Get training from your local fire department in how to properly use a fire extinguisher.
- Install smoke alarms and test them monthly. Change the battery once a year, or when the alarm emits a "chirping" sound (low battery signal).
- Check with your city or county to see if there is a Community Emergency Response Team (CERT) in your area. If not, ask how to start one.

Plan NOW to communicate and recover after an earthquake:

- Select a safe place outside of your home to meet your family or housemates after the shaking stops.
- Designate an out-of-area contact person who can be called by everyone in the household to relay information.
- Provide all family members with a list of important contact phone numbers.
- Determine where you might live if your home cannot be occupied after an earthquake or other disaster.
- Know about the earthquake plan developed by your children's school or day care. Keep your children's school emergency release card current.
- Keep copies of essential documents, such as identification, insurance policies, and financial records, in a secure, waterproof container, and keep with your disaster supplies kits. Include a household inventory (a list and photos or video of your belongings).

Have occasional earthquake "drills" to practice your plan. Share your plan with people who take care of your children, pets, or home.



3.
CREATE DISASTER SUPPLIES KITS

Personal disaster supplies kits

Everyone should have personal disaster supplies kits. Keep them where you spend most of your time, so they can be reached even if your building is badly damaged. The kits will be useful for many emergencies.

Keep one kit in your home, another in your car, and a third kit at work. Backpacks or other small bags are best for your disaster supplies kits so you can take them with you if you evacuate. Include at least the following items:

- Medications, prescription list, copies of medical cards, doctor's name and contact information
- Medical consent forms for dependents
- First aid kit and handbook
- Examination gloves (non-latex)
- Dust mask
- Spare eyeglasses or contact lenses and cleaning solution
- Whistle (to alert rescuers to your location)
- Sturdy shoes
- Emergency cash
- Road maps
- Bottled water
- List of emergency out-of-area contact phone numbers
- Snack foods, high in water and calories
- Working flashlight with extra batteries and light bulbs, or light sticks
- Personal hygiene supplies
- Comfort items such as games, crayons, writing materials, teddy bears

- Toiletries and special provisions you need for yourself and others in your family including elderly, disabled, small children, and animals.
- Copies of personal identification (drivers license, work ID card, etc.)

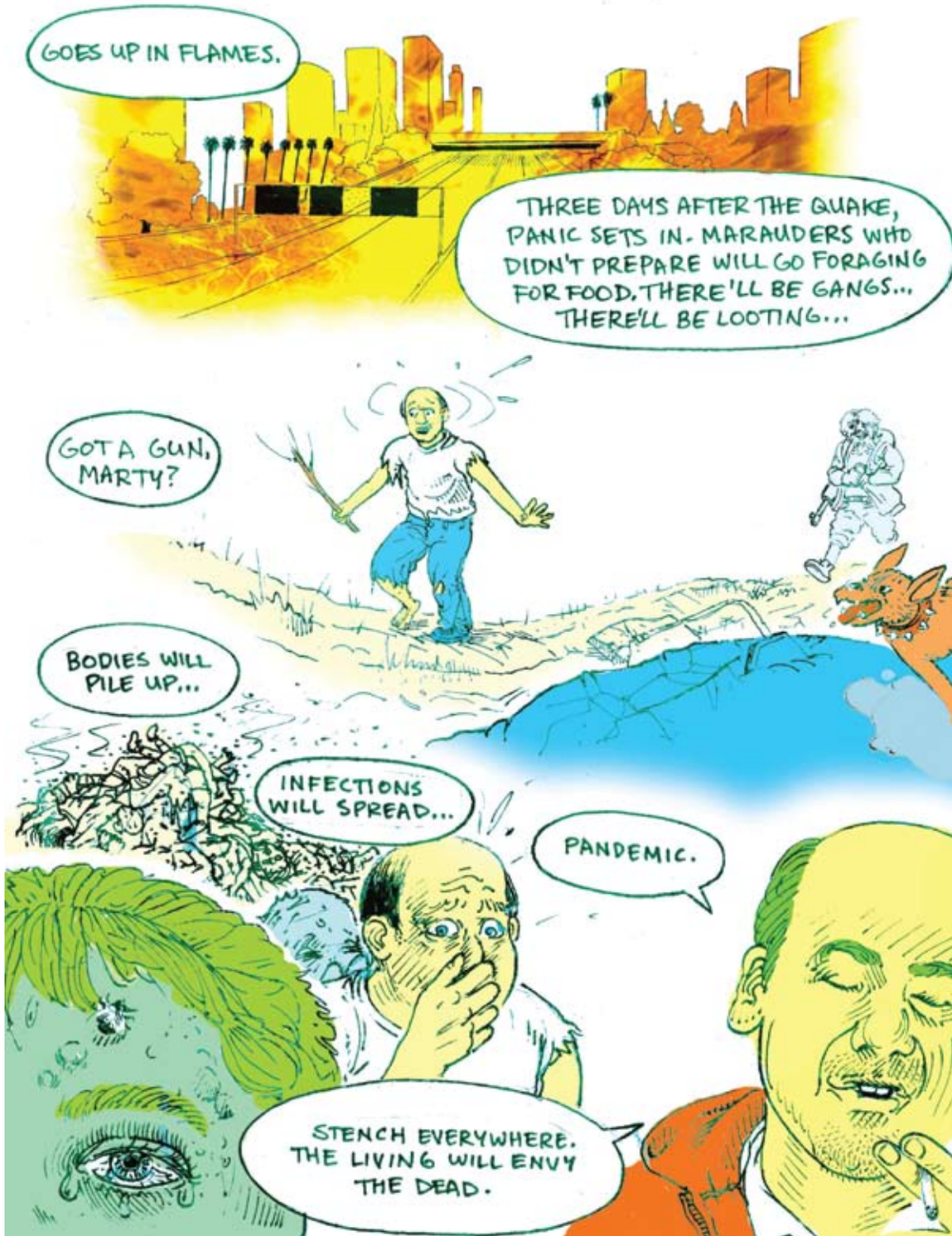
Household disaster supplies kit

Electrical, water, transportation, and other vital systems can be disrupted for several days after a large earthquake. Emergency response agencies and hospitals could be overwhelmed and unable to provide you with immediate assistance. Providing first aid and having supplies will save lives, will make life more comfortable, and will help you cope after the next earthquake.

In addition to your personal disaster supplies kits, store a household disaster supplies kit in an easily accessible location (in a large watertight container that can be easily moved), with a three-day to one-week supply of the following items:

- Wrenches to turn off gas and water supplies
- Work gloves and protective goggles
- Heavy duty plastic bags for waste, and to serve as tarps, rain ponchos, and other uses
- Portable radio with extra batteries
- Additional flashlights or light sticks
- Drinking water (minimum one gallon per person, per day)
- Canned and packaged foods

Use and replace perishable items like water, food, medications, first aid items, and batteries on a yearly basis.



4. IDENTIFY YOUR BUILDING'S POTENTIAL WEAKNESSES AND BEGIN TO FIX THEM

Buildings are designed to withstand the downward pull of gravity, yet earthquakes shake a building in all directions—up and down, but most of all, sideways. There are several common issues that can limit a building's ability to withstand this sideways shaking.

Common building problems

Most houses are not as safe as they could be. The following presents some common structural problems and how to recognize them. Once you determine if your building has one or more of these problems, prioritize how and when to fix them, and get started.

Inadequate foundations.

Look under your house at your foundation. If the foundation is damaged or built in the "pier and post" style, consult a contractor or engineer about replacing it with a continuous perimeter foundation. Look for bolts in the mudsills. They should be no more than 1.8 meters (6 feet) apart in a single story and 1.2 meters (4 feet) apart in a multistory building. Adding bolts to unsecured houses is one of the most important steps toward earthquake safety. This can be done by a contractor or by someone skilled at home maintenance.

Unbraced cripple walls.

Homes with a crawl space should have panels of plywood connecting the studs of the short "cripple" walls. You or a contractor can strengthen the cripple walls relatively inexpensively.

Soft first stories. Look for larger openings in the lower floor, such as a garage door or a hillside house built on stilts. Consult a profession-

al to determine if your building is adequately braced.

Unreinforced masonry.

All masonry (brick or block walls) should be reinforced. Some communities have a program for retrofitting buildings made of unreinforced masonry. If your house has masonry as a structural element consult a structural engineer to find what can be done. Inadequately braced chimneys are a more common problem. Consult a professional to determine if your chimney is safe.

For those who rent

As a renter, you have less control over the structural integrity of your building, but you do control which apartment or house you rent:

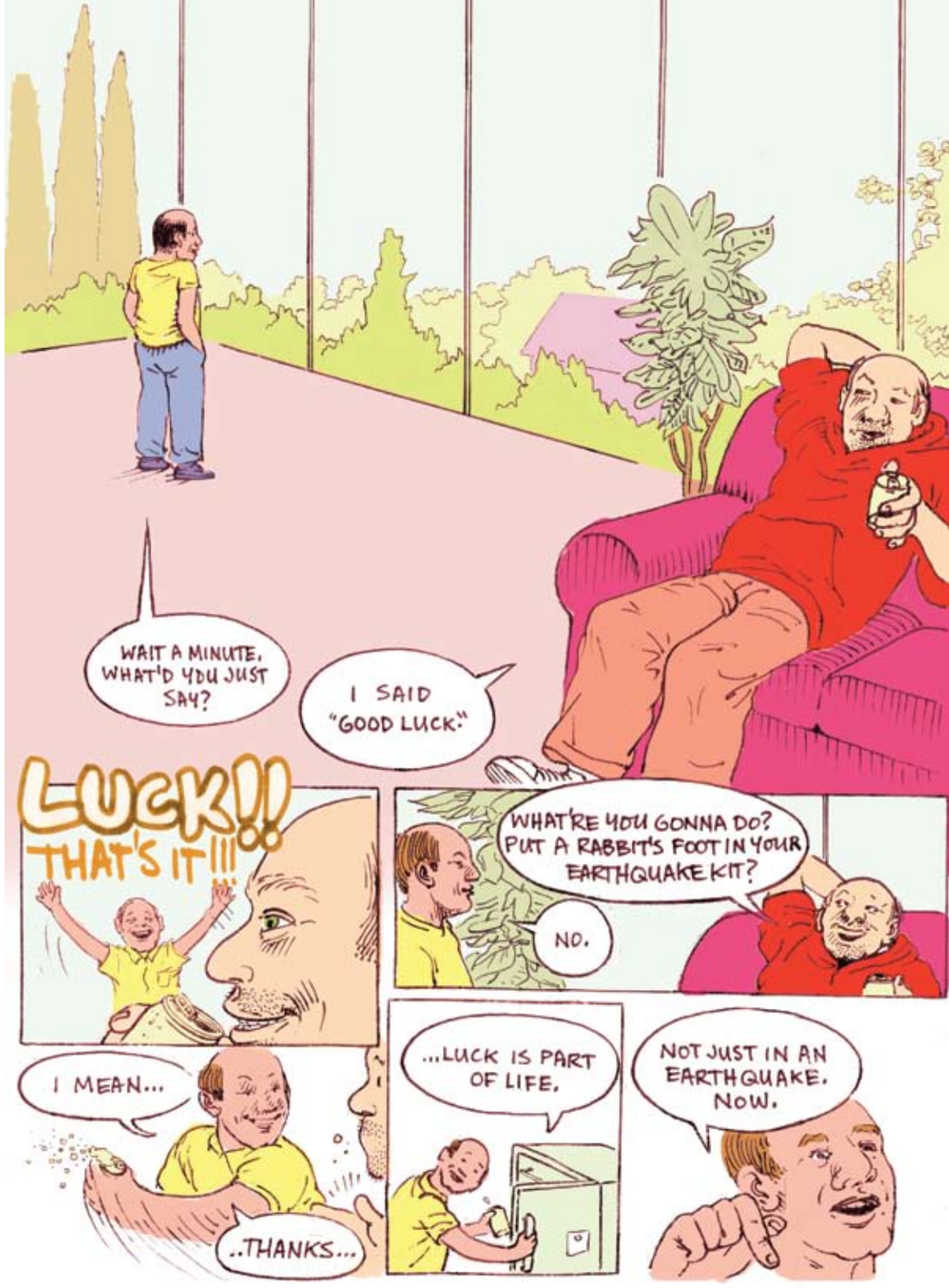
- Structures made of unreinforced brick or block walls can collapse and cause great loss of life.
- Apartment buildings with "tuck-under" parking space openings can also collapse.
- Foundation and cripple wall failures can cause expensive damage but less loss of life.
- Objects attached to the sides of buildings, such as staircases, balconies, and decorations, can break off in earthquakes.

Ask the landlord these questions:

- What retrofitting has been done on this building?
- Have the water heaters been strapped to the wall studs?
- Can I secure furniture to the walls?

If you live in a mobile home...

Look under your home. If you only see a metal or wood "skirt" on the outside with concrete blocks or steel tripods or jacks supporting your home, you need to have an "engineered tie-down system" or an "earthquake-resistant bracing system" (ERBS) installed. An ERBS should have a label on the bracing that says, "Complies with the California Administrative Code, Title 25, Chapter 2, Article 7.5."



5. PROTECT YOURSELF DURING EARTHQUAKE SHAKING: DROP, COVER, AND HOLD ON

The previous sections have concentrated on getting ready for the next earthquake. What should you do during and after earthquakes?

During earthquakes, drop to the floor, take cover under a sturdy desk or table, and hold on to it firmly. Be prepared to move with it until the shaking stops.

The area near the exterior walls of a building is the most dangerous place to be. Windows, facades and architectural details are often the first parts of the building to collapse. To stay away from this danger zone, stay inside if you are inside and outside if you are outside.

If you are...

Indoors:

Drop, cover, and hold on. If you are not near a desk or table, drop to the floor against the interior wall and protect your head and neck with your arms. Avoid exterior walls, windows, hanging objects, mirrors, tall furniture, large appliances, and kitchen cabinets with heavy objects or glass. Do not go outside!

In bed:

If you are in bed, hold on and stay there, protecting your head with a pillow. You are less likely to be injured staying where you are. Broken glass on the floor has caused injury to those who have rolled to the floor or tried to get to doorways.

In a high-rise:

Drop, cover, and hold on. Avoid windows and other hazards. Do not use elevators. Do not be surprised if sprinkler systems or fire alarms activate.

Outdoors:

Move to a clear area if you can safely do so; avoid power lines, trees, signs, buildings, vehicles, and other hazards.

Driving:

Pull over to the side of the road, stop, and set the parking brake. Avoid overpasses, bridges, power lines, signs, and other hazards. Stay inside the vehicle until the shaking is over. If a power line falls on the car, stay inside until a trained person removes the wire.

In a stadium or theater:

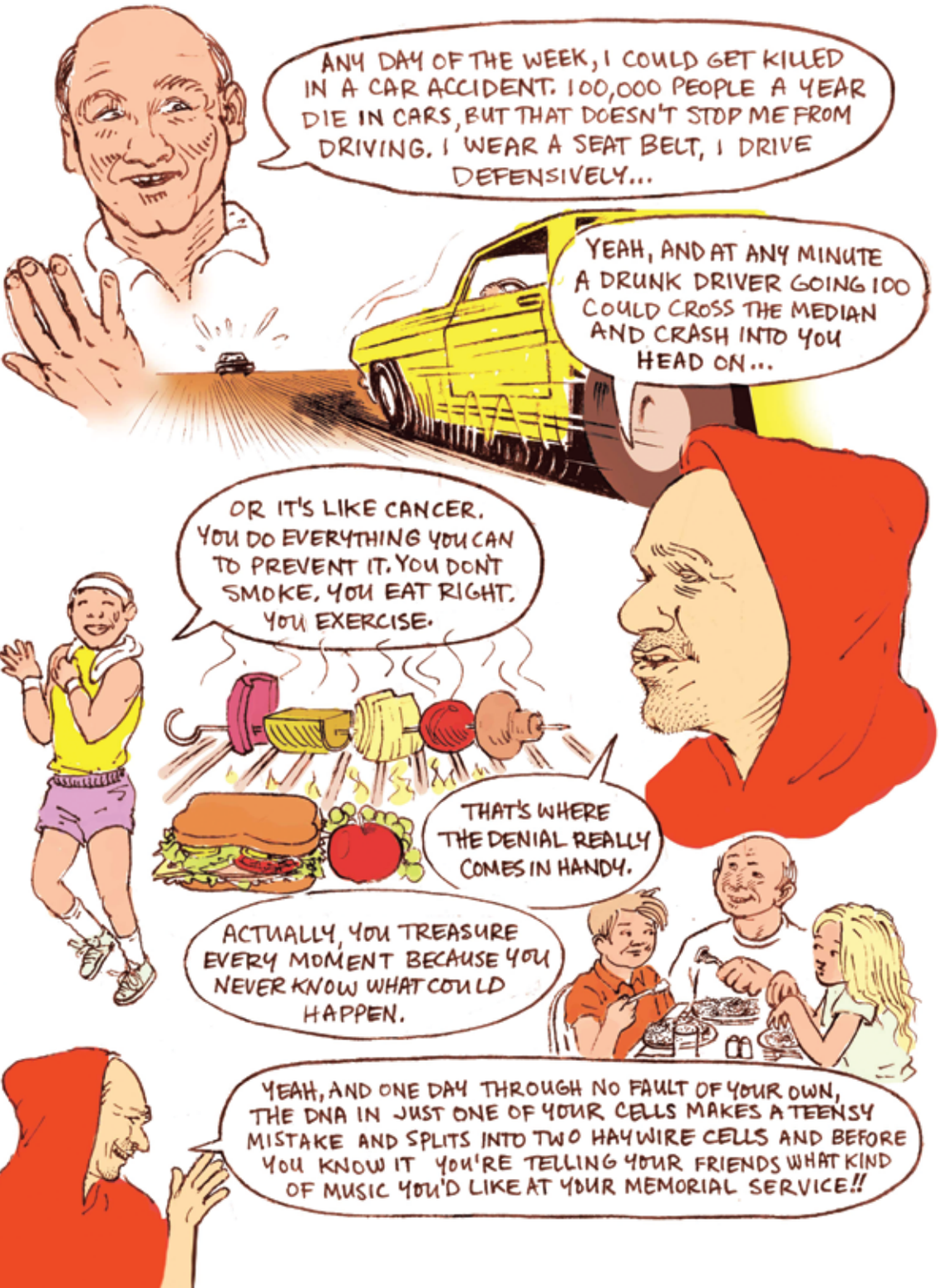
Stay at your seat and protect your head and neck with your arms. Don't try to leave until the shaking is over. Then walk out slowly watching for anything that could fall in the aftershocks.

Near the shore:

Drop, cover and hold on until the shaking stops. Estimate how long the shaking lasts. If severe shaking lasts 20 seconds or more, immediately evacuate to high ground as a tsunami might have been generated by the earthquake. Move inland 3 kilometers (2 miles) or to land that is at least 30 meters (100 feet) above sea level immediately. Don't wait for officials to issue a warning. Walk quickly, rather than drive, to avoid traffic, debris and other hazards.

Below a dam:

Dams can fail during a major earthquake. Catastrophic failure is unlikely, but if you live downstream from a dam, you should know flood-zone information and have prepared an evacuation plan.



6.
AFTER THE EARTHQUAKE, CHECK FOR INJURIES AND DAMAGE

First take care of your own situation. Remember your emergency plans. Aftershocks may cause additional damage or items to fall, so get to a safe location. Take your disaster supplies kit.

If you are trapped by falling items or a collapse, protect your mouth, nose, and eyes from dust. If you are bleeding, put pressure on the wound and elevate the injured part. Signal for help with your emergency whistle, a cell phone, or knock loudly on solid pieces of the building, three times every few minutes. Rescue personnel will be listening for such sounds.

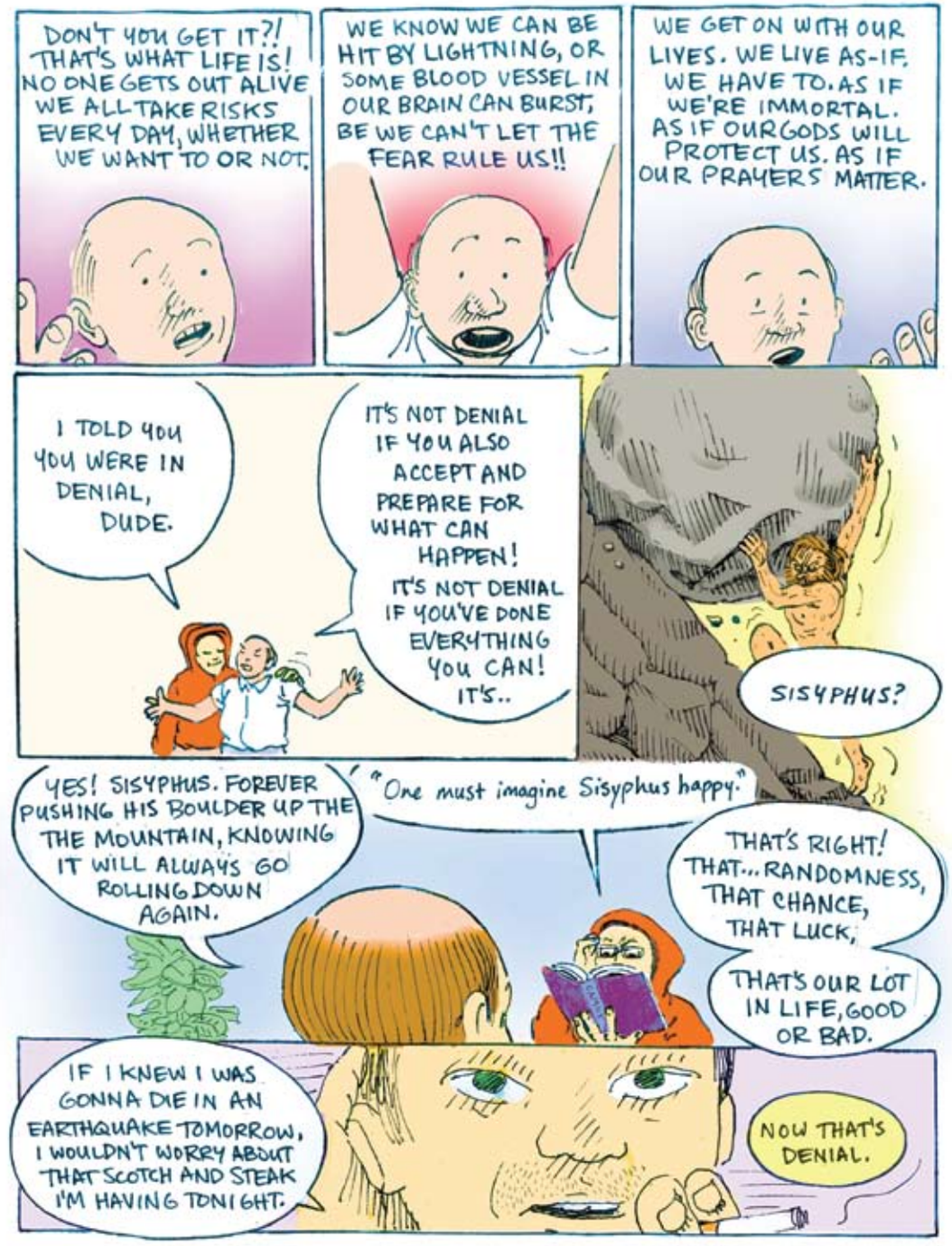
Once you are safe, help others and check for damage. Protect yourself by wearing sturdy shoes and work gloves, to avoid injury from broken glass and debris. Also wear a dust mask and eye protection.

Check for injuries:

- Check your first aid kit or the front pages of your telephone book for detailed instructions on first aid measures.
- If a person is bleeding, put direct pressure on the wound. Use clean gauze or cloth, if available.
- If a person is not breathing, administer rescue breathing.
- If a person has no pulse, begin CPR (cardiopulmonary resuscitation).
- Do not move seriously injured persons unless they are in immediate danger of further injury.
- Cover injured persons with blankets or additional clothing to keep them warm.
- Get medical help for serious injuries.
- Carefully check children or others needing special assistance.

Check for damage:

- FIRE. If possible, put out small fires in your home or neighborhood immediately. Call for help, but don't wait for the fire department.
- GAS LEAKS. Shut off the main gas valve only if you suspect a leak because of broken pipes or the odor or sound of leaking natural gas. Don't turn it back on yourself—wait for the gas company to check for leaks. The phone book has detailed information on this topic.
- DAMAGED ELECTRICAL WIRING. Shut off power at the main breaker switch if there is any damage to your house wiring. Leave the power off until the damage is repaired.
- BROKEN LIGHTS AND APPLIANCES. Unplug these as they could start fires when electricity is restored.
- DOWNED POWER LINES. If you see downed power lines, consider them energized and stay well away from them. Keep others away from them also. Never touch downed power lines or any objects in contact with them.
- FALLEN ITEMS. Beware of items tumbling off shelves when you open the doors of closets and cupboards.
- SPILLS. Use extreme caution. Clean up any spilled medicines, drugs, or other non-toxic substances. Potentially harmful materials such as bleach, lye, garden chemicals, and gasoline or other petroleum products should be isolated or covered with an absorbent such as dirt or cat litter. When in doubt, leave your home.
- DAMAGED MASONRY. Stay away from chimneys and walls made of brick or block. They may be weakened and could topple during aftershocks. Don't use a fireplace with a damaged chimney. It could start a fire or let poisonous gases into your home.



7. WHEN SAFE, CONTINUE TO FOLLOW YOUR DISASTER-PREPAREDNESS PLAN

Once you have met your and your family's immediate needs after an earthquake, continue to follow the plan you prepared in advance. Aftershocks will continue to happen for several weeks after major earthquakes. Some may be large enough to cause additional damage. Always be ready to drop, cover, and hold on.

Your recovery period can take several weeks to months or longer. Take the actions listed below to be safe and to minimize the long-term effects of the earthquake on your life.

The first days after the earthquake...

Use the information you put together in your disaster plan and the supplies you organized in your disaster kits. Until you are sure there are no gas leaks, do not use open flames (lighters, matches, candles, or grills) or operate any electrical or mechanical device that can create a spark (light switches, generators, motor vehicles, etc.). Never use the following indoors: camp stoves, gas lanterns or heaters, gas or charcoal grills, or gas generators. These can release deadly carbon monoxide or be a fire hazard in aftershocks.

Be in communication

- Turn on your portable or car radio for information and safety advisories.
- Place all phones back on their cradles.
- Call your out-of-area contact, tell them your status, then stay off the phone. Emergency responders need to use the phone lines for life-saving communications.
- Check on the condition of your neighbors.

Food and water

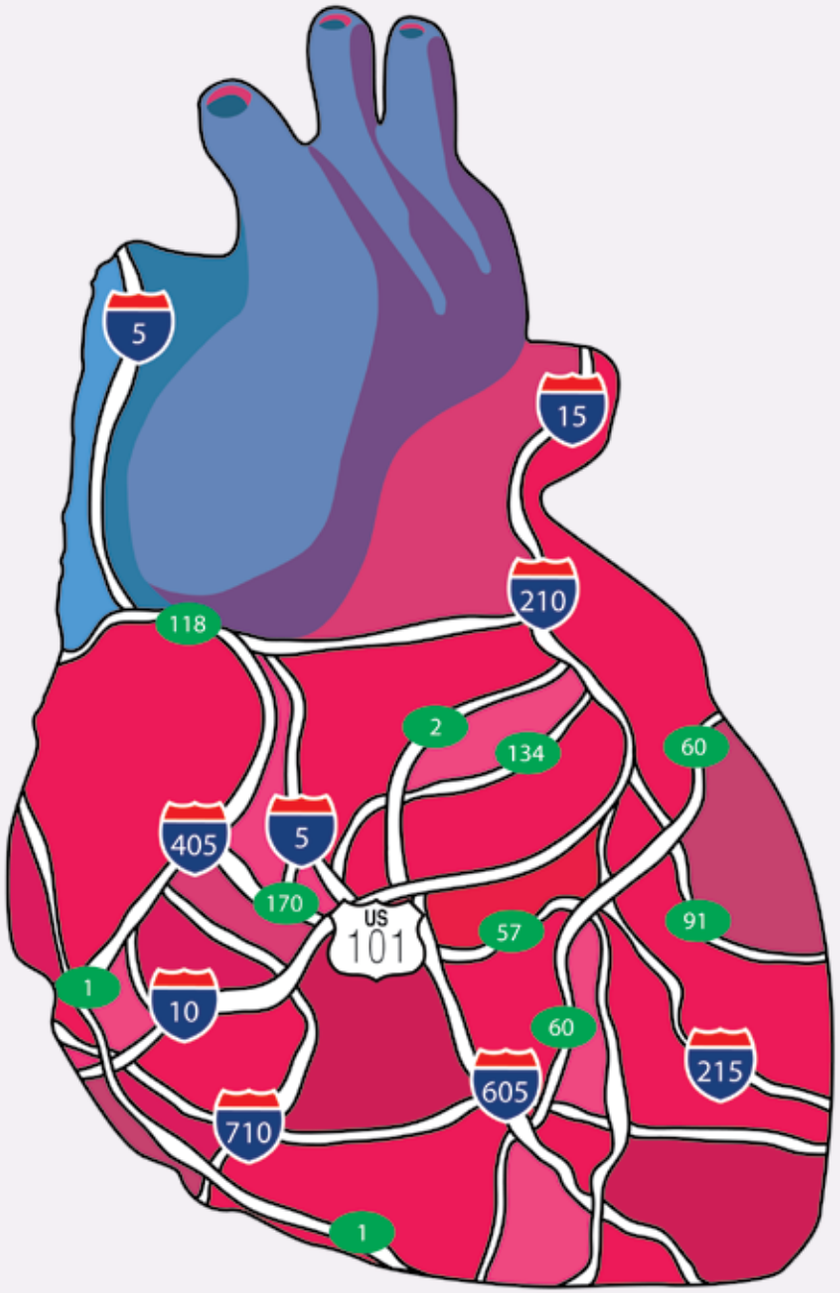
- If power is off, plan meals to use up refrigerated and frozen foods first. If you keep the door closed, food in your freezer may be good for a couple of days.
- Listen to your radio for safety advisories.
- If your water is off or unsafe, you can drink from water heaters, melted ice cubes, or canned vegetables. Avoid drinking water from swimming pools or spas.
- Do not eat or drink anything from open containers that are near shattered glass.

The first weeks after the earthquake...

This is a time of transition. Although aftershocks may continue, you will now work toward getting your life, your home and family, and your routines back in order. Emotional care and recovery are just as important as healing physical injuries and rebuilding a home. Make sure your home is safe to occupy and not in danger of collapse in aftershocks. If you were able to remain in your home or return to it after a few days, you will have a variety of tasks to accomplish:

- If your gas was turned off, you will need to arrange for the gas company to turn it back on.
- If the electricity went off and then came back on, check your appliances and electronic equipment for damage.
- If water lines broke, look for water damage.
- Locate and/or replace critical documents that may have been misplaced, damaged, or destroyed.
- Contact your insurance agent or company right away to begin your claims process.
- Contact the Federal Emergency Management Agency (FEMA) to find out about financial assistance (www.fema.gov/about/process/).

Once you have recovered from the earthquake, go back to Step 1 and do the things you did not do before, or do them more thoroughly. Learn from what happened during the earthquake so you will be safer next time.



Everett Ching

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Mariana Amatullo

THIS publication represents the summation of three years of research, recapturing conversations with and among many extraordinary individuals in scientific and academic institutions, government, community and nonprofit agencies, as well as leading corporate circles. We are immensely indebted for the tremendous insight we gained from this multidisciplinary group of scientists, scholars, and practitioners who were fundamental in shaping our early understanding of the topics of earthquake science, public education, and disaster mitigation. We are pleased to acknowledge many of them by name and organizational affiliation in the partial list compiled for the key resourc-

es of this publication. It is important to note that given the vast knowledge existing in this field, and the number of prominent players who are contributing to the disciplines we examined, our efforts cannot be qualified as exhaustive, but rather as a strategic survey that allowed us to carve out an entry point for engagement.

WE are first greatly indebted to the project's supporters, without whom **The L.A. Earthquake Sourcebook** would not have been possible. We extend our profound thanks for the generosity of Jacobs Engineering, AJ Longo and Associates, the Mabel and Joseph Peluso Foundation, James Lee Witt Associates, the California Seismic Safety Commission, ProtectingAmerica.org, and the National Endowment for the Arts.

We also owe our foremost thanks to each of the seminal authors and preeminent contributors who lent the informed perspectives that provided these volumes with such provocative and intertwining threads of thought. Along with the institutions and organizations they represent, these authoritative experts form an indispensable brain trust for **The Los Angeles Earthquake: Get Ready** project. We greatly appreciate the leadership of this resulting public-private consortium, which overlaps with many of the organizers of **The Great Southern California ShakeOut**, and includes the U.S. Geological Survey, the City of Los Angeles, and the Southern California Earthquake Center, among others.

AMONG the publication's contributors, Lucile Jones, of the U.S. Geological Survey, deserves special thanks. For many in Southern California, Lucy is the voice of seismology. Her many dynamic lectures to our students and faculty provided us with a privileged glimpse at her amazing talent for making hard science easily tangible. We also salute the inspiring advocacy of the California Seismic Safety Commission's Richard McCarthy and Karen Cogan, who took time to inform our students about the Commission's work to reduce earthquake hazards statewide. Dennis Mileti, whose exemplary scholarship contributed immensely to our understanding of effective models for successful public education campaigns to mitigate earthquake hazards, has earned our admiration and gratitude as well. Thanks to Thomas Jordan and Mark Benthien for their close collaboration and for unlocking the outstanding resources of the Southern California Earthquake Center at the University of Southern California, and to the U.S. Geological Survey staff scientist Sue Perry, for allowing our students a first-hand look at active faults while auditing summer field trips for SCEC undergraduates. For their multiple contributions at key junctures of the project, we would like to acknowledge Councilman Greig Smith and his Deputy District Director John Bwarie. John embraced with tireless enthusiasm every aspect of Art Center's project and kept all members of the **ShakeOut** Steering Committee on task. In addition to those mentioned above, a thank you goes to Monica Buchanan, Larry Collins, Dale Cox, Mona Curry, Jim Goltz, Ken Hudnut, Kate Long, Ines Pierce, Jack Popejoy, Margaret Vinci, and Debbie Weiser. For their inspiring institutional leadership, we extend our deep appreciation to Jet Propulsion Laboratory Director Charles Elachi, and to Caltech President Jean-Lou Chameau. We are also honored to include the endorsement of Los Angeles Mayor Antonio Villaraigosa.

COMPLEX collaborations such as this ultimately succeed based on the momentum that builds from joining forces with highly competent partners. We are immensely indebted to James Lee Witt for his invaluable support and ongoing contributions to **The Los Angeles Earthquake: Get Ready** project**.** One of the most influential authorities in disaster prevention and emergency management in the world, James Lee has championed our efforts from day one. We feel privileged to include his masterful lessons in an essay that expands upon his important book, *Stronger in the Broken Places*. We would also like to express our deepest gratitude to Barry Scanlon and two exceptional individuals on James Lee's team who are close collaborators on the project, Mark Guilarducci and M. Reginald B. Salvador.

Thank you to Martin Kaplan for his unique wit, and to the wonderful Johanna Blakley at the Norman Lear

Center, University of Southern California Annenberg School for Communication. Both offered countless contributions to this project—including vital conversations with and connections to their exceptional faculty. Marty's attentive read of the initial manuscript resulted in his proposing the idea of a cunning Q&A that, thanks to his close collaboration with illustrator Darren Ragle, stands like a chapter of a graphic novel, revealing many a reader's conflicting feelings about preparedness, apathy, and denial.

THIS project has relied on the talent, hard work and creativity of many people at Art Center College of Design. We extend our gratitude to the College's department chairs for their educational leadership and belief in the enriching pedagogical model presented by the project. To the board of trustees, staff, alumni, faculty, and students, we say thank you for generously engaging with us at critical stages throughout our work. Special thanks go to project researchers Ann Marie Polsenberg Thomas and Hannah Huang. In addition, we appreciate the contributions of the following colleagues: Mark Breitenberg, Anne Burdick, Nikolai Cornell, Sean Donahue, George Falardeau, Iris Gelt, Jered Gold, Tanja Diezmann, Nik Haffermaas, Rich Haluschak, Christine Hanson, Steven Heller, Michelle Katz, Steven Kim, David Mocarski, Steven Sieler, Vanessa Silverman, Sohini Sinha, and Chuck Spangler.

Conceived as a "visual" source book, this publication is the result of an essential collaboration among a team of exceptional designers and illustrators from and beyond the Art Center community. We commend Ann Field for structuring a studio with the outstanding faculty team of Paul Rogers, Clive Piercy, and Jason Holley, along with inspired guest critiques of the formidable Christoph Neimann. The multidisciplinary student team they led wholeheartedly embraced the challenging task of creating fresh interpretations of these topics. Their singular contributions are a source of delight and provoke lasting reflection. The master illustration essays by Ann Field, Paul Rogers and Christoph Neimann are charged with emotional impact and—along with the student work—add an essential perspective to the publication.

Instrumental in fusing the visual and written components of this intricate puzzle were a handful of colleagues with whom I am fortunate to work closely on a daily basis. Erica Clark, a true mentor, provided wise counsel and encouragement from the inception of this undertaking; her erudite reading of this manuscript has undoubtedly made it a better publication. Elisa Ruffino managed every aspect of three studios that developed media and messaging for the project, interfacing with students, alumni, faculty, and the editorial team to ensure that the flow of work and deliverables were always in the right hands at the right time. Her contributions were instrumental and touched every aspect of the project. Amy Masgai (Illustration Department) and Linda Graybael (International Initiatives), as well as Sheila Low and Lindsay Rapport, from the President's office, were key contributors as well. Very special thanks are also due to Dana Hutt, for dedicating considerable time and writing to this publication, and to the Art Center Development team, Clyde Derrick, Karen Germaine, Charles Edmunds, Wayne Herron, Andrew Kaiser, Melinda Utal-Martinez, Molly Ann Mroczynski, Palencia Turner and the remarkable Andrea Van De Kamp, for their diligent efforts in helping secure the funding streams that have made it possible to produce.

THE L.A. Earthquake Sourcebook would not exist without the creative genius of Stefan Sagmeister, one of the most important and esteemed graphic designers working today. Beyond his talent and intellect, we valued the precision, humility, and ease he brings to everything he touches. In addition to gracing this publication with his exquisite skill, Stefan also conceived the overall signature identity of the project. We are grateful for Stefan's participation, and would also like to acknowledge his associates, Matthias Ernstberger and Joe Shouldice, for their dedication and hard work.

Finally this publication was shaped by a stellar and dedicated editorial team. Aileen Farnan Antonier, Judith Lewis, and David Ulin each brought their individual talent to the pieces that they

contributed. The compelling and rich assembly of profiles, interviews, essays, and narratives are an impressive testament to their collective and hard work. Among them, Judith took up the challenge of weaving all of the voices presented with eloquent and thought-provoking introductions that gave us the gift of a masterful whole, and to her we are especially grateful. Guiding all of us was our managing editor, Gloria Gerace, the true day-to-day force behind this publication. Gloria, working with the incomparable Alex Carswell, orchestrated a seamless working process that essentially enabled the achievement of our collective vision. To her we extend our heartfelt thanks.

THE Los Angeles Earthquake: Get Ready project is a collaborative undertaking of enormous proportions that Art Center led thanks to the unique vision of College President Richard Koshalek. It has been my great joy and privilege to share with Richard the task of bringing to fruition this publication, one of three main components of this multifaceted project. Richard's contagious optimism—and his guiding belief in the creative community's ability to lead the way toward positive change across society—has been of paramount inspiration to us all.

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Commercial Property Owner's Guide to Earthquake Safety, California Seismic Safety Commission, www.seismic.ca.gov, 2006

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THIS IS A SELECTED LIST of organizations and institutions where information on earthquakes and disaster preparedness can be found on their Web sites.

American Red Cross
redcross.org

California Earthquake Authority
earthquakeauthority.com

Caltech Seismological Laboratory
seismolab.caltech.edu

Earthquake Country Alliance
earthquakecountry.info

Earthquake Engineering Research Institute
eeri.org

Federal Emergency Management Agency
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As I look back at the many acclaimed, dedicated, and creative contributors who brought this important project to fruition, I cannot help but reflect on how much I have benefited from the advice and guidance of Martin Friedman. Without a doubt one of the most learned and sophisticated leaders in art and culture today, his expansive worldview and insistence on pursuing one's own voice and instincts has been, and continues to be, an immeasurable inspiration throughout my life and career.

—Richard Koshalek