A Guide to Planning Resources on Transportation and Hazards

DETAILS

44 pages | | PAPERBACK
ISBN 978-0-309-43568-0 | DOI 10.17226/23007

AUTHORS

September 2009

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
TRANSIT COOPERATIVE RESEARCH PROGRAM

Subject Areas: IA Planning and Administration, IV Operations and Safety, V Aviation, VI Public Transit, VII Rail, VIII Freight Transportation, IX Marine Transportation, X Security

Responsible Senior Program Officer: S. A. Parker

Research Results Digest

NCHRP RRD 333—TCRP RRD 90

A GUIDE TO PLANNING RESOURCES ON TRANSPORTATION AND HAZARDS

The enclosed *Natural Hazards Informer* (No. 4, September 2009) was prepared under NCHRP Project 20-59(24) and TCRP Project J-10E by the Natural Hazards Center at the University of Colorado at Boulder. The results of this jointly sponsored NCHRP-TCRP project provide a collective overview of hazard-related research and resources needed by transportation and hazards professionals.

CONTENTS

BACKGROUND

Transportation officials and hazards-related professionals are very concerned about the potential impact of disasters on our nation's transportation infrastructure, and both are working to reduce that impact on multiple fronts. Put simply, though, there is a major gap: transportation officials and hazards professionals don't always speak the same language, and they typically don't access the same resources. With *A Guide to Planning Resources on Transportation and Hazards*, the National Cooperative Highway Research Program (NCHRP), the Transit Cooperative Research Program (TCRP), and the Natural Hazards Center want to begin to bridge that gap. The enclosed *Natural Hazards Informer* (No. 4, September 2009)

- Provides a framework for thinking about the stages of a disaster (mitigate, prepare, respond, and recover) from a transportation perspective, with some description of prevention and security issues;
- Describes the most current and innovative hazards-related research to a transportation audience;
- Introduces research from fields that are not always associated with transportation engineering (including social science, mitigation and land use planning, and policy analysis);
- Reaches out to its audiences in a non-traditional, readable, and engaging format; and
- Introduces the thousands of practitioners and researchers who subscribe to the *Observer* and *Informer* series of the Natural Hazards Center (which has a comparable role in the world of hazards and disaster research and applications to the role the Transportation Research Board [TRB] has in transportation research, applications, and policy) to the relevant resources in the transportation research world.

Readers may also be interested in consulting *NCHRP Report 525: Surface Transportation Security* and *TCRP Report 86: Public Transportation Security*, two series published by TRB in which relevant information is assembled into single, concise volumes—each pertaining to a specific security, infrastructure protection, or emergency management problem and closely related issues.

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

This digest, as well as volumes issued under *NCHRP Report 525: Surface Transportation Security* and *TCRP Report 86: Public Transportation Security,* can be found on the TRB website at http://www.TRB.org/SecurityPubs.

Natural Hazards Informer

Number 4 September 2009

A Guide to Planning Resources on Transportation and Hazards

The Natural Hazards *Informer* is a series that summarizes current knowledge about various aspects of natural hazards for practitioners, researchers, public policy makers, and others.

What this *Informer* does

Our nation's transportation infrastructure (freeways, highways, streets, bridges, public transit lines, bike paths, rail lines, airports, ports, etc.) is arguably the most important piece of infrastructure for the safe and efficient functioning of our nation. We rely on it to get to and from work, to ship our goods to market, and to access any number of important amenities. This issue of the *Informer* introduces a wide range of hazards literature and research that applies to transportation-related emergency management work. It provides an overview of a systems approach to integrated emergency management functions supported by current research, focusing on the importance of a holistic approach to risk reduction. The *Informer* describes how failures in the transportation system resulting from either human-caused or natural disasters can affect all of the other systems that are dependent upon it. Case studies that connect research to practice provide real-world examples of holistic approaches to disaster management in the transportation field.

Who should read it and why

We prepared this issue for transportation officials with emergency response, preparedness, mitigation, and security duties. The case studies are transportation related. That said, anyone with interest in current hazards research will learn something by reading this *Informer*. We explore themes of systems theory, community resilience, connectivity, and security in the context of transportation planning.

Acknowledgements

Andre LeDuc, Lorelei Juntunen, and Emma Stocker wrote and researched this *Informer* with funding from the Transit Cooperative Research Program and the National Cooperative Highway Research Program.

Andre LeDuc, an ECONorthwest Associate, is founder and executive director of the Oregon Partnership for Disaster Resilience and director of Emergency Management at the University of Oregon.

Lorelei Juntunen is a project manager at the Oregon-based consulting firm ECONorthwest. She works at the intersection of policy, land use and transportation planning, and disaster loss reduction.

Emma Stocker is a research associate at ECONorthwest. She spent a year researching and evaluating the mechanisms of recovery in the greater New Orleans area in the aftermath of Hurricane Katrina.

Rob Wyman, ECONorthwest research analyst, also contributed. He specializes in applying geospatial analysis techniques to land use, development, and other public policy issues.

Special thanks to the interviewees whose unique perspectives shaped the case studies: Vincent Ambrosia, Sue Cannon, Thomas Cova, Mike Dietrich, Mike Fischer, Richard M. Gaudiosi, Mike Gavin, Marsha Hilmes-Robinson, Chris Lochra, and Sarah McCaffrey.

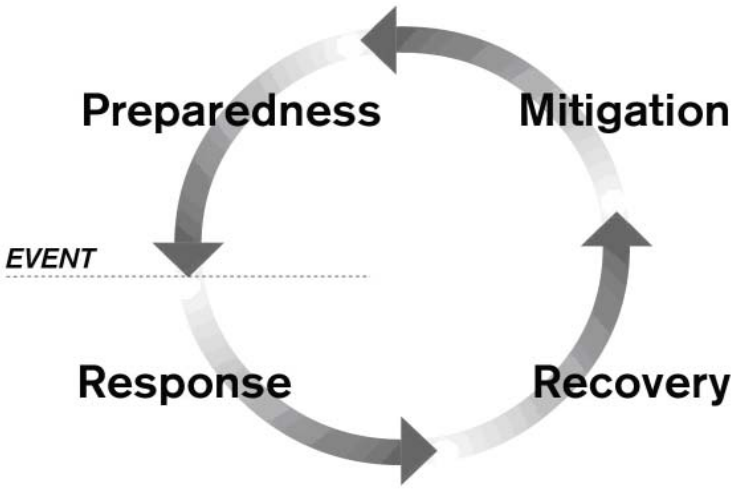
Chapter 1: Introduction to the Disaster Cycle

We live in a world of complex, interrelated systems. Some of those systems are human constructed: the network of roads, sewer and water lines, and buildings we have built to support our towns and cities. Others are natural: the rivers, hills, weather patterns, and geologic forces that shape our environment. Still others are social: the network of connections among people, the governments that provide leadership and services, and the network of businesses that support the activities of our daily lives. Our communities cannot function sustainably unless each of these systems is doing its job.

Disaster events highlight the interconnection and sensitivity of systems: when a disaster causes one of the systems — or even part of one of the systems — to fail, the effects can ripple throughout the population. The transportation system is one of the most important among those that are human constructed, because it connects all systems (people, infrastructure, land, natural features, and the economy) together. Disasters that disable the transportation system can severely disrupt the ability of our economy, government, and communities to function.

For these reasons, it is critically important that the professionals responsible for the security of our transportation systems think holistically about how a transportation system failure could affect all of the other systems that are dependent upon it, and, just as importantly, how the failure of other systems could affect the transportation infrastructure.

One way to begin to do that is to form a new relationship with the disaster cycle. The emergency management profession has developed the concept of the disaster cycle as a basis for disaster management.



The Disaster Cycle

The disaster cycle has four distinct yet interrelated phases — Prepare, Respond, Recover, and Mitigate. The concept of the cycle implies an ongoing process in which communities, businesses, and individuals can plan for and reduce disaster losses.

In the traditional view, the disaster cycle is triggered by an event and begins with the response to that event. The goal is to respond to a specific event so that the loss of life and property is minimized, then rebuild in a manner that reduces future losses. Because of that focus, emergency management programs often prioritize the preparedness and response phases, leaving limited resources to address recovery and mitigation.

A systems approach to emergency management suggests a different understanding of the disaster cycle that balances resources among the four phases. In a holistic

The Four Phases of the Disaster Cycle

Preparedness refers to activities, programs, and systems developed in advance of a disaster designed to build and enhance capabilities of individuals, businesses, communities, and governments at the state and federal levels to support the response to and recovery from future disasters.

Response begins as soon as a disaster event occurs. Response is the provision of search and rescue services, medical services, and access control as well as repairing and restoring communication and data systems during a crisis. A coordinated response plan can help reduce casualties and damage as well as decrease recovery time.

Recovery operations provide for basic needs and restore the community. There are two components in the recovery phase. During the first phase, infrastructure is examined, and repairs carried out to restore water, power, communication, and other utilities. The second phase includes returning to normal functions and addressing future disasters.

Mitigation (or loss reduction) is the act of reducing or eliminating future loss of life and property and injuries resulting from hazards through short- and long-term activities. Mitigation strategies may range in scope and size. But no matter the size, effective mitigation activities can reduce vulnerability and exposure to risk from disasters.

A Guide to Planning Resources on Transportation and Hazards

An All-Hazards Approach to Vulnerability Reduction

The National Strategy for Homeland Security, last updated in October 2007, is a unified document that articulates how national initiatives are building capacity for disaster prevention, protection, response, recovery, and preparedness. The National Strategy was created to "mobilize and organize our nation to secure the U.S. homeland from terrorist attacks." **

This *Informer* advocates for an all-hazards preparedness approach, bracing the national infrastructure, economy, and social systems for human-induced as well as natural disasters. In fact, calling out the specific need to protect against and prevent human-induced hazards enhances the traditional four-stage disaster cycle by incorporating the unique challenges posed by human-induced hazards. National initiatives, such as the National Incident Management System and others described in the National Strategy for Homeland Security, are tremendous tools that facilitate response and recovery regardless of the cause of the disaster. Reducing vulnerability to and bolstering national defenses against one type of hazard can help to prepare for other hazards as well.

DEFINITION OF KEY TERMS

Human-Induced Disaster: An event directly caused by the action or inaction of a human element from intent, negligence, or error.
Natural Disaster: An event in which human systems are significantly and negatively affected by the natural environment.
Prevention: Action taken to avoid an incident or to intervene to stop an incident from occurring that includes applying intelligence and other information to a range of countermeasures. *
Protection: Actions taken to manage the overall risk to systems or their interconnecting links resulting from exposure, injury, destruction, incapacitation, or exploitation. *
Preparedness: A cycle of planning, organizing, training, equipping, exercising, evaluating, and improving the operational capacity intended to prevent, protect against, respond to, and recover from disaster events. + *
Response: Resources are employed to save lives, protect property and the environment, and preserve the social, economic, and political structure of the jurisdiction through 1) gaining and maintaining situational awareness; 2) activating and deploying key resources and capabilities; 3) effectively coordinating response actions; and 4) then, as the situation permits, demobilizing. +
Recovery: In the short term, recovery is an extension of the response phase in which basic services and functions are restored. In the long term, recovery is a restoration of both the personal lives of individuals and the livelihood of the community. +
Mitigation: This is ongoing activity designed to reduce exposure to, probability of, or potential loss from hazards. *
Resiliency: This refers to the ability of a system to maintain its function during or to recover from an event. *

Sources:
* National Infrastructure Protection Plan 2006 (NIPP)
+ National Response Framework, January 2008 (NRF)
**National Strategy for Homeland Security 2002.

systems approach to disaster risk reduction, the goal is not to mitigate or respond in isolation, but to efficiently spend limited resources to reduce the loss of life and property and to speed post-disaster response and recovery. This approach prevents losses by mitigating risk whenever possible, by planning for continuity of operations, and by preparing for response and recovery efforts before disasters occur in a manner that recognizes that resources for risk-reduction activities are limited. Recent research supports the idea that shifting to a more balanced allocation will more effectively reduce the loss of life and property over the long term: for every $1 spent on mitigation, between $4 and $7 are saved in response and recovery (Abramovitz 2001; Multihazard Mitigation Council 2005).

This perspective is especially important when planning for the impact of disasters on the nation's transportation infrastructure. The smooth functioning of transportation systems is fundamental to our nation's economic, social, and built infrastructure: road, rail, and airlines tie our communities together. In other words, it is critical infrastructure requiring special attention. It makes economic sense to integrate hazards-related concepts into the everyday work of transportation officials: rebuilding roads, bridges, and other transportation infrastructure that have been destroyed is much more expensive than building them in a disaster-resilient way to begin with. Further, response and recovery activities rely on the continued functioning of the transportation system. Leveraging resources for loss reduction can save lives.

Because all systems are interrelated, no one person or agency could ever hope to reduce an entire population's risk. The security of our transportation system is important to the lives and safety of everyone residing in this country, but those with transportation emergency management responsibilities cannot assure that the system is secure without the cooperation of a diverse set of partners: local, state, and federal governments; citizens; the business and nonprofit communities; and the many agencies responsible for our roads, wildlands and parks, housing, sewer and water infrastructure, social services, and so on. Without these partnerships and a system in place to coordinate mitigation activities, the efforts will be piecemeal and could miss critical components of the system.

Chapter 2: Overview

The *Informer* is broadly divided into two sections:

The first section presents an overview of key issues to consider in a systems approach to emergency planning and response. It also includes some practical resources relevant to those working in the transportation field. It is organized into four categories — economy, people, infrastructure, and land and development — that represent the major systems that might be affected by transportation system failures (and vice versa: disruptions in these systems may also hinder the full functioning of the transportation system itself):

ECONOMY. Hazards impact our economy in obvious ways: by directly interrupting the systems that allow us to do the work that drives the nation's productivity. But they also have a subtler effect. The way our nation chooses to invest its collective resources can increase the vulnerability of our economic and other systems. This part of the *Informer* highlights the ways in which disasters can impact the economy and the ways in which our economic system incurs disaster vulnerability.

PEOPLE. The life and safety of individuals is a key concern for anyone with responsibility for emergency planning, but not all individuals are equally vulnerable to disasters. Many researchers have focused on identifying solutions to the increased vulnerability experienced by elderly, low income, and minority residents. This part presents research describing the ways in which differential vulnerability is incurred.

INFRASTRUCTURE. Some researchers have dedicated their efforts to defining ways to improve the security and resilience of our built infrastructure: the network of roads, bridges, ports, and railroads; sewer, water, and electrical lines; and buildings that are critical components of the day-to-day functioning of our lives. This part of the *Informer* examines research related to infrastructure resilience.

LAND, DEVELOPMENT, AND NATURAL SYSTEMS. Finally, the *Informer* focuses on how we develop our urban and rural areas, and the ways in which our development patterns can impact our disaster resilience both positively and negatively.

The second section of the *Informer* puts the theory into action. It examines specific transportation-related case studies to show how a systems approach to risk reduction can improve community resilience. Each case study highlights a transportation emergency management activity and explains how a holistic, systems approach can improve community resilience.

This publication is not a comprehensive literature review. It provides categories of research to help define systems that are linked to and by our transportation system. Though much research has been done internationally, the literature review and case studies focus only on the United States in order to provide a relevant and focused overview of the expanding fields of transportation and disaster management. Included after each section is a list of additional resources.

Case Studies

Case Study 1: The PortSTEP Program: Integrating and Coordinating Port Security in a Multimodal Transportation System discusses key themes in security, including standards, collaboration and coordination, and formal agreements, as important steps toward a more secure and resilient port.

Case Study 2: Evacuation and Fires in Southern California illustrates the effectiveness of preparedness measures and discusses vulnerable populations, communication and command, shelter-in-place, land use, and future evacuation challenges.

Case Study 3: Hazard Mitigation and an Alternative Approach to Transportation and Land Use in Fort Collins, Colorado describes efforts in Fort Collins, Colorado, to reduce risk in floodplains and landslide prone areas through strategic land use decisions that incorporate alternative modes of transportation in high-risk areas.

A Guide to Planning Resources on Transportation and Hazards

Chapter 3: The Economy and Hazards

Hazards impact our economy in some obvious ways: by directly interrupting the systems that allow us to do the work that drives the nation's productivity. But they also have a subtler effect. How our nation chooses to invest its collective resources can increase or decrease the vulnerability of our economic and other systems. This chapter highlights the ways in which disasters can impact the economy and the ways in which our economic system incurs disaster vulnerability.

Research Overview

THE LINK BETWEEN DISASTERS AND THE ECONOMY

The *economy* is broadly defined as the arena in which goods and services are produced, exchanged, distributed, and consumed. National and local economies are vulnerable to a wide range of shocks. Changes in the economy can dramatically affect individual lives. Even without the shock of a disaster, the economy fluctuates over time as a result of many uncontrollable variables like population change, technological advancement, or even the resignation of a well-known CEO.

When a disaster occurs, it affects the economy in several ways, including:

- Loss of economic value in property and public infrastructure resources, job loss, and business slowdowns and failures;
- Loss of tax revenue as property values and businesses are affected;
- Shift of personal and government financial resources to recovery efforts, and needs for additional resources to support recovery creating public and private debt;
- Increases in consumer product prices if the disaster affects resource availability or distribution, causing goods to become more scarce relative to demand; and
- Decrease in the economic potential of society by exacerbating poverty and disabling lifelines.

Economic conditions can also affect hazard vulnerability: a weak economy reduces individual and family financial resources that are crucial to prepare for and recover from a disaster, thereby lessening community resilience.

Economic impacts are exacerbated when the transportation system is not functioning properly to distribute goods and services after an event. At the same time, economic disasters directly reduce our collective ability to pay for new transportation infrastructure and to maintain the existing one.

WHAT DOES ECONOMIC PREPAREDNESS LOOK LIKE?

Strong economic preparedness plans involve both the public and private sector in efforts to assure that the economy can withstand the shock of a disaster. In general, a community interested in assuring economic preparedness would:

- Aim for economic diversity to reduce dependence on a single, vulnerable industry. For example, increasing fuel costs not only drive up the cost of transportation, but also the price of the goods that are transported, such as construction materials and food. In this case, diversified energy use would reduce market disruption if a disaster interrupted the fuel supply.
- Anticipate the vulnerability of key industries to a variety of natural and human-caused disasters. Communities that recognize high-risk industries and work with the private sector to mitigate that risk may also have greater disaster resilience.
- Pay attention to infrastructure and plan to pay for reconstruction. In a major disaster, partnerships with the federal government may help, but will probably not fully fund reconstruction. Some resources must be provided by local public and private organizations. Transportation infrastructure is largely public. Having a plan in place to assure that it can be rebuilt is critical to recovery success. Research has shown that, to the extent that funding and other resources do not have to be borrowed, the economy exhibits resiliency but may also forego short-term growth potential by saving money rather than investing it (Freeman et al., 2004). These are trade-offs that economic preparedness plans must consider.

WHO IS RESPONSIBLE FOR ECONOMIC PREPAREDNESS?

Perhaps the best sign of a well-prepared economy is a set of investment priorities, throughout all sectors, that reflects realistic risks and vulnerability:

> All-hazards preparedness not only takes into account the unique risks and vulnerabilities faced by transportation infrastructure, but also fosters networking with industry and community organizations that rely on transportation.

Public investment in preparedness can bolster economic resilience by fostering diverse economies as well as encouraging private sector preparedness and mitigation activities. Many communities have implemented economic development plans that improve their resilience to economic shocks by creating quality jobs and diversifying the economy. Federal policies such as the Disaster Mitigation Act of 2000 (see sidebar, page 10) encourage communities to consider the economic impact of disasters and to mitigate against those impacts. Public policy could also effectively guide patterns of production, consumption, and trade away from vulnerability by creating incentives for less volatile inputs, reducing foreign dependence, minimizing the environmental impact of development through building codes, and implementing policies that reduce socioeconomic disparities. Importantly in the context of this *Informer*, the transportation system is a major public sector investment critical to successful economic preparedness.

There is also a critically important role for the private sector in economic preparedness. Disasters stunt economic growth by redirecting investments toward response and recovery and generally increasing uncertainty in the affected markets. Employers can ensure their business's continuity by helping their community and employees prepare for disasters. Public and private investments in preparedness not only lessen the direct impacts of a disaster but can also reduce longer-term direct and indirect consequences.

Individuals carry responsibility for community economic resilience in the face of disaster. In the United States, individual households are expected to use private resources to prepare for, respond to, and, to a large extent, recover from disasters. Simple, inexpensive mitigation in the home (such as strapping water heaters or attaching a home to its foundation) can save lives and dollars and reduce the public toll of a disaster. Privately held insurance policies help spread the cost of recovery to a broad pool of resources that would otherwise remain unavailable.

Individuals, businesses, and governments can and should independently take steps to create economic resiliency. At the same time, partnerships between jurisdictions, across levels of economic actors, and among agencies, are necessary to implement successful preparedness and mitigation measures.

One example of regional coordination to build economic resiliency is the Pacific NorthWest Economic Region (PNWER), a forum for binational cooperation that encourages global economic competitiveness and natural environment preservation. Founded in 1991, it is the only statutory, nonpartisan, nonprofit, public/private partnership in North America. In 2001, PNWER launched the Partnership for Regional Infrastructure Security and the PNWER Disaster Resilience and Homeland Security Program. PNWER coordinates annual "critical infrastructure interdependency exercises" that address regional security and disaster concerns. Exercises to date have encompassed cyber threats, earthquakes, pandemic disease, and large-scale physical attacks. PNWER's work to improve the ability of the Pacific Northwest to protect critical infrastructure (including transportation infrastructure), withstand economic and physical shocks, and recover from all-hazards disasters is nationally recognized as a best-practices model of planning for resiliency (PNWER 2007).

Definitions

Direct impact refers to the physical damage resulting from an event. **Indirect impact** refers to the ramifications of the initial, direct, impacts of the event.

The term **macroeconomic** indicates an economy-wide phenomenon.

The **public sector** is the part of the economy that involves the goods and services provided by and for government. The **private sector** is the part of the economy not controlled by government, operated for profit.

Market benefit-cost analysis is a method of economic valuation measuring all positive and negative outcomes of an action in terms of the cost to the economy.

KEY CHALLENGES IN ECONOMIC PREPAREDNESS

The costs associated with each phase of the disaster cycle are increasing over time. According to the insurance company Swiss Re, there were 335 catastrophes in 2007, claiming 14,600 lives with total financial losses of $70.6 billion, only about 40 percent of which was insured (Swiss Re 2008). In 1970, there were about 100 catastrophes, both human-caused and natural. Swiss Re says average annual losses in constant dollars have increased from about $4 billion a year during the 1970s and 1980s to $23 billion annually over the past 20 years. Even without an increase in the number of catastrophes, economic losses will almost certainly go up in the future as more people move into the danger zones.

A Guide to Planning Resources on Transportation and Hazards

> By looking at community risk from a more holistic and systems approach we can better identify a community's resource exposure sensitivity, which equates to the relative importance of the system, and, last but not least, the community's ability to respond and recover or its resiliency.

The full cost of a disaster includes indirect and macroeconomic loss and those realities can burden generations into the future:

Indirect losses are consequences of the direct impact of the crisis. They can include wage, production, customer, and valuation losses stemming from business interruption and closure. Small businesses are especially vulnerable (Alesch 2001; Olshansky 2005; Pelling 2002).

Macroeconomic losses provide an aggregate picture of the wide-ranging effects of a disaster. Fluctuations in gross domestic product (GDP), inflation, and changes to consumption and resource allocation patterns reveal the national impact of disasters (Freeman et al. 2004).

By looking at community risk from a more holistic and systems approach we can better identify a community's resource exposure (e.g., buildings, roads, utilities, social structure and services, etc.) sensitivity, which equates to the relative importance of the system (e.g., vulnerable populations or economy) and, last but not least, the community's ability to respond and recover—its resiliency. Based upon this evaluation we can develop strategies for both short-term and long-term mitigation and disaster risk reduction (LeDuc 2006).

PRIORITIZE MITIGATION

The growing frequency and destructiveness of disasters, paired with increasing economic assets in hazard-prone areas, is drawing national attention to the value of mitigation (Ganderton 2005).

Reducing the consequences of natural and human-induced disasters on the economy through mitigation planning is clearly cost effective considering that long-term disruption of the social or physical environment creates a host of economic problems.

Mitigation efforts try to reduce the impact of an event before it occurs. Implementing these actions often requires an understanding of how systems work together. For example, prioritizing which overpass in a network of collectors, arterials, and highways is most vulnerable and should be targeted for hardening requires engineering, evacuation modeling, mapping of other critical infrastructure to assure access (to hospitals, for example), and an understanding of daily commute patterns. Mitigation planning must account for a complex interaction of economic and social factors.

IMPROVE CONTINUITY PLANNING

Organizations that are able to maintain normal operations or restart them quickly after a disruption stand to not only profit themselves but also to be able to aid the recovery of the rest of the community. The extent to which an organization can support the individual recovery of its employees can also minimize the cost of the event to the distressed community as a whole (Paton 1999).

For transportation-related agencies, like other agencies and businesses, continuity planning is the key to assuring that critical services are not interrupted. Transportation agencies must plan not only to harden infrastructure and plan for recovery, but also to assure that administrative and business functions continue: that employees can get to work, that critical data from computer systems will be available, and that paychecks can still be processed if a disaster occurs.

Business continuity (BCP)/continuity of operations (COOP) plans can be made independently of other preparedness work or in conjunction with it. BCP/COOPs allow an organization to continue to provide its core service even during uncertain times. Each business or organization must evaluate its function within the economic and social context it occupies. Planning for continuity creates resilience to internal and external shocks ranging from the loss of staff, from financial crisis, or from an earthquake. Next, the identification of resources to support the continuity of services will reassure employees as well as customers of organizational resiliency. Proactive planning can calm fears before and during a crisis, improving overall organizational efficiency.

INVOLVE THE INSURANCE AGENCY

The insurance industry is a major stakeholder in loss reduction, both because it has incentive to reduce the impacts of a disaster and because it has tools that can be used to encourage mitigation and preparedness activities. But not every home and business has insurance to cover disaster losses even though most of the financial loss sustained after a disaster is due to property damage. The extent of coverage, rates, and deductibles are highly variable across providers as well as policyholders. But the basic premise is the same: when an individual or business buys insurance, they are protected against a set amount or type of loss. Actions to encourage the use of insurance could spread recovery costs more broadly.

Insurance companies can charge larger deductibles and premiums on policies that carry higher risk or that are more vulnerable to disasters, or they can require those covered by their policies to take certain risk-reduction actions. In this way, the availability and cost of insurance can be an indicator of the risk and vulnerability of a property. It may even serve as a catalyst for mitigation. "Al-

though insurance is not considered a mitigation measure, a carefully designed insurance program can encourage the adoption of loss reduction measures through economic incentives such as premium reductions and lower deductibles" (Petak 1998).

WHAT DOES THE RESEARCH IMPLY FOR TRANSPORTATION PLANNING?

According to the Bureau of Transportation Statistics, transportation-related goods and services contributed over $1 trillion dollars to the U.S. gross domestic product (GDP) in 2002, more than 10 percent of the total. Transportation is the fourth largest contributor to GDP, after housing, healthcare, and food. Funds allocated toward creating, maintaining, and protecting transportation capital and the productivity potential of transportation infrastructure should reflect this importance to the economy.

Transportation planning agencies can ensure the resiliency of systems within their jurisdiction through:

- Continuity planning to address operational and physical system weaknesses and to assure that personnel can attend to the business, maintenance, and repair functions of transportation agencies after an event;
- Prioritizing system improvement projects and other investments in a manner that takes community economic resilience into consideration; and
- Collaboration with economic development agencies and private sector partners to understand the needs of key local and regional industries.

All-hazards preparedness not only takes into account the unique risks and vulnerabilities faced by transportation infrastructure, but also fosters networking with industry and community organizations that rely on transportation or could create indirect consequences for transportation sectors in the wake of a disaster. Through preparedness, response, recovery, and mitigation efforts, a resilient transportation sector will support the efficient functioning of other sectors. Its central role in the U.S. economy during both normal activity and disaster events makes transportation resiliency of utmost importance for future prosperity.

Federal Mitigation Funding

A report submitted to Congress by the National Institute of Building Science's Multihazard Mitigation Council (MMC) highlights that "FEMA mitigation grants are cost effective, often leading to additional non-federally funded mitigation activities, and have the greatest benefits in communities that have institutionalized hazard mitigation programs." The report also points out that for every dollar spent on mitigation, society can expect an average savings of $4 (MMC 2005). Even so, between 1988 and 2001 FEMA "spent about $28 billion on recovery…but less than 10 percent of that (about $2.6 billion) on mitigation over the same period" (Ganderton 2005). Undoubtedly, response and recovery efforts should be adequately funded but allocations toward mitigation and preparedness at all levels are falling short.

To begin to remedy that, Congress passed the Disaster Mitigation Act of 2000. The act establishes a "national disaster hazard mitigation program" with a twofold mission: 1) to reduce the loss of life and property, human suffering, economic disruption, and disaster assistance costs resulting from natural disasters; and 2) to provide a source of predisaster hazard mitigation funding that will assist states and local governments in implementing effective hazard mitigation measures designed to ensure the continued functionality of critical services and facilities after a natural disaster (U.S. Congress 2000).

Many communities work directly with transportation engineers and planners to identify and prioritize transportation projects such as seismic retrofits for funding.

A Guide to Planning Resources on Transportation and Hazards

Useful Resources and Documents

Continuity of Operations Planning Guidelines for Transportation Agencies
www.trb.org/news/blurb_detail.asp?id=5612

This report is designed to assist transportation agencies in evaluating and modifying existing operations plans, policies, and procedures, as called for in the National Incident Management System. TRB's *NCHRP Report 525: Surface Transportation Security* and *TCRP Report 86: Public Transportation Security* publications have jointly published *Continuity of Operations (COOP) Planning Guidelines for Transportation Agencies*. The report is Volume 8 in each series.

CREATE Homeland Security Center
www.usc.edu/dept/create/

The Center for Risk and Economic Analysis of Terrorism Events (CREATE) Department of Homeland Security Center of Excellence's mission is to improve the nation's security through the development of advanced models and tools for the evaluation of the risks, costs, and consequences of terrorism, and to guide economically viable investments in homeland security.

Disruption Impact Estimating Tool – Transportation (DIETT): A Tool for Prioritizing High-Value Transportation Choke Points

www.trb.org/news/blurb_detail.asp?ID=6202

DIETT is an electronic analytical tool that calculates direct transportation and economic impacts of an event that precludes the use of a transportation choke point (TCP). It prioritizes TCPs on the basis of these criteria. DIETT does not calculate replacement costs. Using DIETT's prioritized sets of outputs, along with other risk information, decision makers will be able to better focus their capital resource, security, and emergency preparedness planning.

Expect the Unexpected: Prepare Your Business for Disaster
www.sba.gov/idc/groups/public/documents/sba_homepage/serv_disprep_planningguide.pdf

This site provides a series of preparedness steps organized by hazard type.

Standard Checklist Criteria for Business Recovery
www.fema.gov/business/bc.shtm

The Federal Emergency Management Agency offers a guide to creating a recovery manual appropriate for business, including questionnaires to ensure a comprehensive plan.

Continuity of Operations Planning
www.ready.gov/business/plan/planning.html

The site provides tools to assist businesses in creating a continuity of operations plan to improve the likelihood that a company will survive and recover from a disaster. It suggests identifying critical operations and creating a flow chart to understand the business processes.

Institute for Business and Home Safety: Open for Business
www.IBHS.org

IBHS provides a comprehensive disaster planning toolkit for businesses.

Public Entity Risk Institute website
www.riskinstitute.org

The PERI site offers research, education, and training resources.

Chapter 4: People and Hazards

The lives and safety of individuals are a key concern for anyone with responsibility for emergency planning. But not all individuals are equally vulnerable to disasters. Many researchers have focused on identifying and suggesting solutions to the increased vulnerability that elderly, poor, and minority residents experience. This part of the *Informer* presents research describing the ways in which differential vulnerability is incurred.

Research Overview

THE LINK BETWEEN SOCIAL SYSTEMS AND HAZARDS

The connection between social forces and disasters is a complex web of cause and effect. Disasters, to be called disasters, necessarily occur in a human context: an earthquake in the middle of the trackless desert is not a disaster. Alesch defines a disaster as an extreme event that "causes extensive damage to some or all of the built environment, the people and institutions that inhabit the built environment, and the relationships among those people and institutions and the outside world" (Alesch 2001).

Every phase of the disaster cycle — preparedness, response, recovery, and mitigation — takes place within the context of a mix of social forces. Social context affects the way people understand and respond to the disaster cycle. It determines the distribution of resources prior to, during, and after the event. Social patterns can even increase vulnerability and induce a disaster. Efforts to prepare for disasters must take into account relevant social forces contributing to the makeup of the affected communities.

TRANSPORTATION, HAZARDS AND SOCIAL SYSTEMS

Globally speaking, all populations are becoming more disaster prone. The United States is experiencing the same trends as the rest of the world: migration to coastal and urban areas, increasing socioeconomic disparities, population growth, and overwhelmed social services coupled with what many scientists feel is a growing frequency of severe weather events. Our collective exposure to hazards is increasing as more assets and more people locate in hazardous areas. Technology, while capable of mitigating a large portion of risk, cannot be the only line of defense. A holistic approach to hazard mitigation addresses behaviors, attitudes, and social barriers that are counterproductive to creating a resilient society.

The burdens of a disaster are not distributed evenly across physical locations or social groups. Transportation systems, in their planning, construction, maintenance, and day-to-day functioning can lead to greater levels of vulnerability — or they can mitigate these disparities for vulnerable groups.

MOBILITY AND IMMIGRATION

The overall mobility rate for the United States has declined since the mid-20th century. Even so, the Population Reference Bureau (PRB) reported that between 2002 and 2003, more than 40 million people (approximately 7.5 percent of the population) moved across state lines. They noted that young adults 20 to 29 years old are the age group with the highest mobility; about one-third of people in that age group moved in 2003.

Estimates reveal that states in the western and southern United States are experiencing the largest influx of population. While international immigration does contribute to the increase, a 2007 PRB survey showed that "only 11 percent of people who moved across state lines in 2005 and 2006 were born outside the United States" (Mather 2008). Counties in Florida, California, Nevada, Arizona, Colorado, and Utah saw the fastest growth, according to the survey. Nationally, suburbs and commuter towns surrounding large metropolitan areas have also experienced growth.

Rural midwest and upper Great Plains counties are not only losing population, but also the ability to replace aging populations. Rural communities and urban areas alike face the challenge of replacing aging infrastructure. However, the ability of rural areas to fund replacement and renewal, let alone mitigation actions, is significantly impaired by demographic changes, which doubly increases the vulnerability of remaining populations.

Growth via migration into urban areas brings its own challenges. The inability of infrastructure and services to keep pace with population can heighten the effect of even a small hazardous event. For example, new arrivals to an urban area require more housing. The rush to accommodate them sometimes leads to development in hazard-prone areas. Poorly enforced or nonexistent building codes allow for structures unfit to withstand local environmental hazards. Land use patterns can induce excess water use through inappropriate landscaping, as in the Southwest. Construction material choices and reinforcement techniques may leave midwestern homes susceptible to tornados. Coastal homes built too close together can compound earthquake and hurricane damages.

SOCIOECONOMIC SEGREGATION

Transportation is both a means and an end for social connectivity, bringing people and goods closer together. A transportation system can contribute directly and indirectly to socioeconomic segregation by providing greater or lesser degrees of access. When limited access, poor service, or lax maintenance decreases the performance of the transportation system serving already underprivileged groups, transportation is both an indicator and cause of the disparities and resulting disaster vulnerabilities.

In the United States, individual households are expected to use private resources to prepare for, respond to, and, to a large extent, recover from disasters. This expectation means poor households are automatically disadvantaged when confronting hazards. Social divides along socioeconomic lines concentrate resources within some groups while compounding vulnerabilities for others.

When groups having fewer resources occupy hazard-prone areas, disasters will compound and exacerbate social inequalities. Recovery research demonstrates that trends — be they developmental, social, or economic — accelerate after a disaster. Events surrounding Hurricane Katrina serve as an example of a historically segregated population receiving inadequate mitigation support (in terms of evacuation) and an unequal distribution of recovery resources.

The transportation system plays a key role in connecting people to the resources that they need every day, as well as in a disaster event. Isolation can compound the effects of a disaster. In many communities, poor residents have reduced access to transportation and other resources. Many inner city neighborhoods remain underserved by schools and parks (which often play a critical role in disaster response) and walkable amenities like grocery stores (Massey and Denton 1998).

MITIGATION FOR VULNERABLE GROUPS

Planning mitigation actions and creating a resilient system is an opportunity to decrease the vulnerability of communities. As discussed in the land use section, the process of creating a mitigation or recovery plan disseminates information about hazards and local resources and can illustrate which groups are most vulnerable to a given hazard. An effective course of mitigation actions will include vulnerability estimates, proactively lessening risk and exposure across all sectors of the population. Disaster mitigation is therefore "an important opportunity to integrate hazard mitigation with economic development and social justice, achieving the multiple objectives needed for a resilient system" (Godschalk 2003).

Access to transportation (both public and private) will continue to be a critical issue. In an evacuation, system capacity is not the only issue. Many people in urban settings, elderly or infirm residents, physically isolated groups, and those without private vehicles will require additional assistance. As we discuss in Case Study 1 (page 25), communities that may face more immediate threats, that have fewer entry and exit options, and that could become isolated should receive first consideration in evacuation plans. Improving multimodal connectivity will reduce the vulnerability of physically and socially isolated groups, thereby improving disaster resiliency.

Density also proves challenging for a transportation system in a disaster situation. Urban populations and poor communities may have many people who rely on public transportation for their evacuation. As U.S. coastal

In Practice: Mapping Vulnerability

Cutter et al. (2000) examined the social and geographic vulnerability of one county in South Carolina. They collected three types of baseline data on local hazard areas and vulnerable populations:

1) biophysical vulnerability (e.g., event frequency and delineation of hazard zones);

2) social (socio-demographic characteristics); and

3) place vulnerability (the interaction of the first two).

Data were then incorporated into individual Geographic Information Systems (GIS) layers. Physical hazards mapped included flood zones; hurricane wind and storm surge intensities; and rail, highway, and fixed-facility chemical accident zones. Social characteristics were used to create a geographically based index of social vulnerability. Factors included the number of women, nonwhite residents, people under 18 and over 65, and housing information.

To complete the study, Cutter et al. added an information layer that included infrastructure, lifelines, and special needs locations (e.g., schools, heath centers, shelters, and nursing homes) as a way to contextualize place vulnerability. Overlaying each piece of information creates an all-hazards estimate of vulnerability and assets. Cutter et al. conclude that "knowledge of the spatial distribution of biophysical and social vulnerability, coupled with a geographic understanding of lifelines, can help counties to better prepare for disasters and to develop mitigation strategies to reduce future loss."

In a study like this, the transportation system can be mapped both as a source of hazards (chemical spills, for example) and as a capability (access to transportation systems reduces overall vulnerability). The map highlights the ways in which well-planned transportation systems can improve community resilience even as they present sources of risk.

populations face record-breaking hurricane seasons and as the country braces against potential terrorist strikes, transportation planners must anticipate the need to evacuate local and regional transit-dependent populations.

Transportation systems can also contribute to hazards. Pollution and chemical spills are transportation-induced side effects that more often affect low-income and minority groups because these communities often live in cheaper housing near freeways and along rail lines. Evaluating the indirect hazards incurred by a population's proximity to a transportation corridor is often overlooked as a vulnerability until after an event.

RESILIENCY

A community's resiliency is determined by a large number of factors including the severity of the disaster, resources immediately available, the resiliency of critical infrastructure, and the impact of the disaster on social networks that knit a community together. Variability is inherent in social resiliency. Understanding social resiliency requires a continual process of evaluation, assessment, and capacity building. "Hazard mitigation must become a process fed by the continuous acquisition of different mixes of new knowledge from different fields. Human adaptation to hazards must become just as dynamic as the ever-changing problems presented by hazards themselves" (Mileti 1999).

Godschalk (2003) proposes some tactics for enhancing social resilience:

Ongoing Vulnerability Reduction: Regularly prepare, publish, and update detailed vulnerability analyses that describe and map potential hazards with probable impacts. Include vulnerability reduction in the comprehensive, neighborhood, and capital improvement plans. Set vulnerability reduction targets incorporating disadvantaged populations, and call for funding and program resources.

Distribution of Hazard Capacity: Provide hazard awareness information, funding, and training to community groups and coordinate hazard mitigation with existing efforts (e.g., conservation or economic development).

Commitment to Broad Hazard Mitigation: Develop hazard mitigation as an item on the public agenda.

Messaging, Cultural Competency, and Risk Reduction

Many communities recognize the need to reduce risk and vulnerability for underrepresented groups, but have not yet implemented outreach and planning activity programs that can be evaluated. Several fields of research provide robust models of public involvement that can be borrowed for risk reduction related to hazards. Here we discuss research from public health and health care that has created a rich field of outreach strategies, appropriate messaging about individual behavior change, and other tools that could be applied in the emergency management arena.

Some ideas from the public health field:

Over time, "healthy" has evolved from being measured at the individual level — in terms of reduction in activities that result in negative health outcomes (such as smoking or eating a diet too rich in fat and cholesterol) — to a population-based assessment that considers the social, economic, and physical factors that influence a community's or an individual's health (Lindsay 2003).

As health professionals strive to accomplish concrete goals such as nutrition standards or disease transmission reduction, public health outreach strategies have evolved to address the obstacles presented by social, economic, or physical factors hindering message dissemination.

The concept of cultural competency (or appropriateness) in communication about health issues has proven a crucial tool to gain access, trust, and action with vulnerable groups. Rooted strongly in psychology, a culturally competent approach understands that "it is not information per se that determines action, but how people interpret it in the context of their experience, beliefs, and expectations. Perceptions of risk are culturally and socially constructed, and social groups construct different meanings for potentially hazardous situations" (McIvor and Paton 2007).

The actions of residents facing Hurricane Katrina highlighted the necessity of understanding the decision-making processes of vulnerable groups, and researchers in the public health field took notice. For example, researchers found that many non-evacuees who had personal transportation found additional logistical barriers came into play in their decisions, such as being unable to afford gas or lodging in a host city.

Researchers also learned that a larger definition of household or family was in play. Invalid fathers-in-law and diabetic great aunts could not be easily moved to another location, or the compact car belonging to a mother of two could not fit the carless sister and cousins who lived next door.

These are just a few of the social, cultural, and physical realities that were not planned for or accommodated in the evacuation (Eisenman et al. 2007; Eldar et al. 2007).

This highlights the fact that communication about health issues before, during, and after a disaster is critical. It can mean the difference between life

A Guide to Planning Resources on Transportation and Hazards

Establishment of Network Communications: Establish a multipurpose community communications network, used to implement mitigation and preparedness.

Recognition of Equity Standards: Work with residents to define needs and appropriate mitigation techniques. Work with community leaders to adopt equity standards and goals and to galvanize resources for mitigation.

Establishment of Sustainable Social Systems: Prepare vulnerable populations and places for survival.

Establishment of Sustainable Economic Systems: Establish procedures ahead of time to assist businesses with supply, customer, and resource interruption.

Establishment of Sustainable Natural Systems: Restore environmental systems as part of the protective system of the area.

WHAT DOES THE RESEARCH IMPLY FOR TRANSPORTATION PLANNING?

Social trends, such as mobility and income stratification, shape the composition of communities in the United States. To prepare the public for disasters and to build resiliency to their impacts, transportation planners must understand the needs of all population groups. The characteristics of a community can either aid in or become an obstacle to preparedness, response, recovery, and mitigation efforts.

Increased awareness of the social ramifications of transportation decisions will help planners to allocate resources efficiently and in a way that addresses the inequalities of risk and vulnerability. As population growth occurs, planners will need new tools to deal with system growth and preparedness (from funding to material) and to enhance the capacity of transportation systems. In this resource scarce climate, transportation investments should be evaluated not only on their mitigative role but also on indirect or longer-term impacts on vulnerability.

Transportation planners can work with other sectors such as social service providers and public health officials as they plan for disasters. Coordination and collaboration will help all sectors better understand vulnerable groups, thoroughly account for community assets, and effectively build a disaster resilient society.

and death for those who at the same time experience health issues and disaster vulnerability.

SOME KEY LESSONS LEARNED IN PUBLIC HEALTH RESEARCH, APPLIED TO EMERGENCY MANAGEMENT

1. TAILOR OUTREACH ACTIVITIES. Outreach about the disaster cycle and health concerns are similar: they aim to reduce risk. James et al. (2007) discusses several factors already incorporated in health information standards that could be used in disaster cycle outreach. They include: reading ability (grade-level), language, dissemination (e.g., television, radio, web, or newspaper), and content (e.g., length, inclusion of recovery information, and connectivity to the community through representation of similarity).

2. START EARLY. Providing information and support in a disaster situation is most effective if the foundation for response and action is laid during non-emergency times. In Minnesota, the Emergency and Community Health Outreach (ECHO) coalition regularly reached out to state residents with limited English proficiency. Engaging communication officials at the state, county, and local levels increased publicity.

Partnering with the public television system allowed ECHO to produce and air a series of 20-minute programs in several languages. They addressed culturally significant issues such as Lyme disease, severe weather warnings, pediatric illnesses, and poisonous mushrooms. ECHO is building capacity with Web- and phone-based materials with the goal of being able to broadcast live during a disaster to update residents (Schnirring 2008).

3. GATHER DATA. The Kentucky Outreach and Information Network (KOIN) has created a network of resources. Together with the Kentucky Cabinet for Health and Family Services, KOIN sought out individuals, agencies, media, and institutions to assist in communicating with special needs and vulnerable population.

A database was developed incorporating information about vulnerable populations such as the following:

- Blind and visually impaired persons,
- Individuals who are deaf or hard of hearing,
- Individuals with disabilities,
- Elderly persons,
- Non-native or limited English speakers,
- Those in need of literacy outreach, and
- Those in need of remote/rural services.

KOIN provided workshops, information guides and clearinghouses, and training exercises to ensure that KOIN member groups could facilitate the flow of information and services in the event of an emergency (Kentucky Cabinet for Health and Family Services 2008).

Collaboration among fields allied around vulnerable groups (including public health, social work, planning, and others) exponentially expands the research, planning, funding, implementation, and overall justification for mitigation activities.

Useful Resources and Documents

Are You Ready? An In-Depth Guide to Citizen Preparedness
www.fema.gov/areyouready/

This site offers an in-depth guide to individual, family, and community preparedness. It provides information on specific hazards as well as step-by-step suggestions on how to get information about local hazards, evacuation, and shelter information.

Disaster Preparedness for People with Disabilities
www.disability911.com

The Disaster Preparedness for People with Disabilities website includes links to webcasts, books, and newsletters, training materials, and other resources aimed at helping centers for independent living, public officials, emergency preparedness officials, and people with disabilities stay prepared.

Rural Assistance Center
www.raconline.org

The Rural Assistance Center provides health and human service information for rural communities.

Red Cross Preparedness Site
www.redcross.org/services/prepare/0,1082,0_239_,00.html

Individuals and families can find disaster preparedness guides here.

Crisis and Emergency Risk Communication
www.bt.cdc.gov/cerc/pdf/CERC-SEPT02.pdf

This publication from the Centers for Disease Control and Prevention draws from theories of crisis management, issues management, communications, and psychology, coupled with lessons learned from the field. It addresses a number of topics critical to successful public outreach and communication during an emergency situation.

The Social Vulnerability Index (SoVI)
www.sovius.org

This tool measures the social vulnerability of U.S. counties to environmental hazards. The index is a comparative metric that facilitates the examination of the differences in social vulnerability among counties. It graphically illustrates the geographic variation in social vulnerability. It shows where there is uneven capacity for preparedness and response and where resources might be used most effectively to reduce the pre-existing vulnerability. SoVI is also useful as an indicator in determining the differential recovery from disasters.

A Guide to Transportation's Role in Public Health Disasters
www.trb.org/news/blurb_detail.asp?ID=6266

TRB's *NCHRP Report 525,* Volume 10, examines development of transportation response options to an extreme event involving chemical, biological, or radiological agents. The report contains technical information on chemical, biological, and radiological threats, including vulnerabilities of the transportation system to these agents and consequence minimization actions that may be taken within the transportation system in response to events involving these agents.

The Role of Transit in Emergency Evacuation
onlinepubs.trb.org/Onlinepubs/sr/sr294.pdf

TRB Special Report 294: The Role of Transit in Emergency Evacuation explores the capacity of transit systems serving the nation's 38 largest urbanized areas to accommodate the evacuation, egress, or ingress of people from or to critical locations in times of emergency.

Chapter 5: Infrastructure: Lifelines During Disasters

Some researchers have dedicated their efforts to defining ways to improve the security and resilience of our built infrastructure: the network of roads, bridges, and railroads; sewer, water, and electrical lines; and buildings that are critical components of the day-to-day functions of our lives. This chapter examines some of that work.

Research Overview

THE LINK BETWEEN DISASTERS AND INFRASTRUCTURE

Critical infrastructure is the lifeline of society. It is defined by the Department of Homeland Security (DHS) as "the assets, systems, and networks, whether physical or virtual, so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, public health or safety or any combination thereof."

In this country, most people take for granted the ability to turn on the water, plug in an appliance, and easily get from place to place on a daily basis. When a natural disaster occurs, the vulnerability of essential services will in large part determine the capacity of response efforts, loss of life, economic consequences, and the scope of short- and long-term recovery.

Calling these infrastructure systems "lifelines" emphasizes the fact that the social and economic losses resulting from their malfunction or breakdown are almost always greater than the dollar value of the asset itself. DHS notes 18 critical infrastructure systems and key resources, including the network of water, utility, and sewer lines; treatment plants; roads, sidewalks, and bridges; communications lines; the network of emergency services and hospitals; commercial facilities; and national monuments and icons.

The transportation system accommodates over 4 trillion miles of passenger travel annually. It is a complicated combination of modes, users, service goals, regulating bureaucracies, and funding agencies. The national transportation system necessarily supports and relies on other infrastructure to fulfill its function. Understanding how lifeline infrastructure systems overall, and transportation in particular, interact within the context of the disaster cycle is an important step toward building overall resiliency against disasters.

Infrastructure systems are connected in many ways, some of which may not be visible or obvious at first. Systems can be linked through the people that operate, maintain, or use the system; the hardware that facilitates their operations; or the services that they provide. Disruption of one of these components can impact the ability of the others to function. Three main factors can determine the impact of a hazard event on infrastructure: the degree to which infrastructure systems are integrated, the magnitude of the initial disruption, and the strength of fail-safe measures within and between systems. "Outage effects will either die out as they move further away in time and space from the initiating event, limiting overall damage, or they will gather force in successively stronger cascading waves until part or all of the infrastructure network breaks down" (Little, 2002).

Critical Infrastructure and Key Resources

The federal strategy for infrastructure security is based on the National Infrastructure Protection Plan (NIPP) and supporting sector-specific plans (SSPs). Together they provide a framework for the coordination of roles and responsibilities for security stakeholders.

There are 18 critical infrastructure systems: agriculture and food; banking and finance; chemical; commercial facilities; commercial nuclear reactors, materials, and waste; dams; defense industrial base; drinking water and water treatment systems; emergency services; energy; government facilities; information technology; national monuments and icons; manufacturing; postal and shipping; public health and healthcare; telecommunications; and transportation systems. Key resources are publicly or privately controlled resources essential to minimal operations of the economy or government, including individual targets whose destruction would not endanger vital systems but could create a local disaster or profoundly damage the nation's morale or confidence.

Sector-specific plans identify the unique strengths and weaknesses of the sector and provide guidelines for the coordinated use of resources and the implementation of the NIPP.

Sources: U.S. DHS 2006, U.S. DHS 2007

SECURING INFRASTRUCTURE: REDUNDANCY, REINFORCEMENT, AND READINESS

There are three broad paths to mitigation for physical aspects of critical infrastructure systems: redundancy, reinforcement, and readiness. First, engineering infrastructure systems to withstand extreme stress from natural forces and securing them from human-induced harm is critical. This is typically known as "reinforcement" or "hardening" of infrastructure.

Second, system redundancy, as a mitigation and preparedness strategy, implies an interchangeability of the linkages between points. Depending on the system under consideration and identified risks, this can be implemented as many paths and access points or as the ability of the material being conducted by the system to access a different mode of transportation or transmission: people can be transported by cars or by trains and information can move via brochures, the Internet, or face-to-face communication. A redundant system can maintain connectivity even if a disaster disrupts one link by ensuring that other sections can still be used. Finally, readiness means being prepared to fix a service disruption, should one occur.

Communication systems, which are essential for a safe and efficient emergency response, provide a good example of how redundancy and reinforcement of infrastructure can increase community resilience. Here are some examples of best practices in communication systems response:

System redundancy: In the wake of the terrorist attacks on September 11, 2001, responders based in different jurisdictions could not communicate because of incompatible technology or protocol. During Hurricane Katrina aboveground telecommunication systems were knocked out by the force of wind, rain, and water. As a result of these lessons, many jurisdictions are implementing multi-agency communications plans and activities. In the Charlotte, North Carolina, region, fire, police, and medical services spanning a 12-county area have installed an integrated and redundant communications system. Satellite phones and a ham radio network serve as backups. Their system not only facilitates regional communication, but it offers many layers of redundancy to assure critical information can be relayed in emergency situations (U.S. DOT 2006).

System reinforcement: Advances in technology make physical reinforcement of communication systems ever more possible. Burying fiber optic cable in hurricane-prone regions reduces the likelihood of outages caused by storms. The 2003 East Coast power outage highlighted the need to increase the self-sufficiency of cell phone transmitter stations after most expended their backup batteries in only a few hours (U.S. DOT 2006).

System readiness: This can be as simple as having trained professionals on call to repair a downed power line or as complex as an intergovernmental agreement to send emergency responders to the scene of a regional crisis. Being prepared to fix the problem does not necessarily mean that a single organization has to repair a system malfunction independently. It does imply that, as additional assistance is mobilized, first responders can triage the situation and do what is necessary to restore immediate service needs, such as returning power to hospitals or shelter sites, clearing main transportation arteries of debris, or distributing a vaccine to essential personnel who have the skills to help others. "Cell on Wheels" (COW), "Cell in a Box" (CIAB), and "Cell on Light Trailer" (COLT) are all terms for a transportable, temporary cellular network hub. Often used to boost network coverage during non-emergency situations such as large conventions or sporting events, they are indispensible in the event of a disaster. Facing seasonal tornados that can ravage communications infrastructure, the Kansas City Metropolitan Area established an agreement with a local cell phone carrier stipulating that in an emergency the company will provide COW services to the region (U.S. DOT 2006).

Strengthening the ability of any critical infrastructure system to serve its function in an emergency situation will save time, money, and lives. Many transportation engineers and planners already consider ways to reinforce the transportation system and create redundancies. Assuring multiple paths are available to any important site (hospitals, downtown employment centers, etc.) and focusing on multimodal transportation systems are ways to provide redundancy in the transportation system that can be helpful during the response and recovery periods of a major event. Reinforcement to assure the physical strength of transportation facilities is a critically important consideration, especially for bridges, tunnels, and overpasses. Transportation agencies engage in readiness activities regularly when mapping traffic detour routes in anticipation of construction or by building dedicated rush hour lanes—viewed through a disaster cycle lens, these practices build awareness of system strength and weaknesses and increase capacity for flexibility during emergencies.

However, isolated improvement of system redundancy, reinforcement, and readiness is no longer enough to protect the transportation system or the populations and sectors it serves. Implementing redundancy, reinforcement, and readiness measures in coordination with other critical infrastructure systems and testing the ability of a multitude of systems to respond together under emergency scenarios will support disaster resiliency overall.

INCLUDING LIFE CYCLE COST ANALYSIS

To estimate loss and vulnerability, analysis must go beyond a focus on the weakness of a single asset or the potential damage of one disaster scenario. Applying a framework of life cycle cost analysis incorporates changing environmental risks, infrastructure deterioration, long-term maintenance costs, and urban growth. It was noted that 40 percent of municipalities in the United States use life cycle cost analysis to inform their long-term maintenance deci-

A Guide to Planning Resources on Transportation and Hazards

sions (Chang 2003). Even so, many municipalities do not account for disaster impacts and mitigation measures in their analysis, leaving public infrastructure poorly maintained. Only by including the cost incurred to society, the economy, and other critical systems when weak infrastructure fails or is disrupted in a disaster scenario will the real and potential cost of deferred maintenance be revealed.

In 2005, federal funding fell short of meeting national need, providing $850 million, or less than 10 percent, of the cost to fully maintain infrastructure systems. Deferring maintenance may ease immediate bottom line problems, but it increases costs in the long run. Letting infrastructure deteriorate not only increases social, economic, and overall infrastructure vulnerability but neglected repairs become hazards themselves. Even as the transportation sector of the economy contributed $1.047 trillion dollars (almost 10 percent) to the GDP in 2001, poor road conditions cost U.S. drivers $54 billion a year in repairs. Congestion (wasted time and fuel) costs the economy $63 billion a year. As the population grows, so will the demand on our critical infrastructure systems (ASCE 2005b).

THE CHALLENGE TO MAINTAIN INFRASTRUCTURE

Deteriorating infrastructure impacts the economy and the quality of life across the country. The 2005 Report Card for America's Infrastructure published by the American Society of Civil Engineers (ASCE) grades the nation overall at a D. The ASCE estimates that the United States will need to invest $1.6 trillion over five years to repair critical infrastructure and meet the needs of the current population. However, their figure does not account for future population growth and the corresponding need for new infrastructure (ASCE 2005b).

Government at all levels must reconcile growing infrastructure maintenance needs with increasing materials costs, population growth, tax revenue shifts, decreases in federal funding, and increased demand for other public services. Over time the equation is only getting more unbalanced. Even though sound engineering and fiscal management strategies, such as pavement preservation, are shown to increase the life span over which the nearly 4 million miles of public roads nationally can remain serviceable, funding shortfalls force municipalities to delay maintenance. Whether you consider roads, sewers, bridges, communication lines, or power transmission conduits, deferred maintenance is an unsustainable approach to national infrastructure systems, decreasing the overall strength of the system. It is costlier in the long run.

The transportation system is valued at more than $1.75 trillion dollars. So transportation maintenance is a sound investment in more than one way (National Center for Pavement Preservation 2008). The efficient transportation of people, goods, and services reduces overhead costs brought on by repairs or congestion. Maintaining safe modes of transit will prevent disasters and can reduce the response and recovery time. Also, maintenance work can spur job growth and technological advancement: "A U.S. DOT study concludes that for each $1 billion of federal spending on highway construction nationwide, 47,500 jobs are generated annually. If we invested in our infrastructure at the level of $1.6 trillion over the next five years, as many as five million jobs would be created" (ASCE 2005a).

WHAT DOES THE RESEARCH IMPLY FOR TRANSPORTATION PLANNING?

Transportation infrastructure is more than the network of roads, bridges, and waterways; it links society to the other critical infrastructure lifelines. Every day people travel to work, to school, to a hospital, or to the store, but it is during a disaster when these usually simple tasks are most poignant and important. It is during times of crisis when political will, planning tools, and funding sources focus on strengthening the links between transportation and other infrastructure systems. Strengthening system security and increasing preparedness efforts should not have to wait for a disaster to occur to become priorities.

Transportation infrastructure has reached its capacity in many places in the nation. Renewal and replacement is underfunded at the same time that the system is being asked to facilitate growth. This poses a challenge for planners who want to prepare the transportation system to be disaster resilient. National efforts are emerging (along with funding) to identify, create, and implement strategies to harden critical infrastructure protection. Transportation infrastructure preparedness is of particular interest. Strategies for transportation resiliency can include the incorporation of new engineering and monitoring technology, coordination between infrastructure systems, quantitative risk assessment, and scenario modeling. Preparedness actions are part of a cycle. Preparing it to withstand and recover from a disaster can facilitate response and recovery actions. In turn, response and recovery activities lead to future mitigation and preparedness efforts. Transportation planners can build and maintain a system that is a leader throughout the disaster cycle.

All transportation capital investments should be viewed through the lens of mitigation: does the project help, hurt, or is it neutral in regards to the agency's risk posture and resiliency?

Useful Resources and Documents

Federal Highway Administration Best Practices in Emergency Transportation Operations
ops.fhwa.dot.gov/OpsSecurity/

This site presents the results of 30 FHWA workshop series.

Guidelines for Vulnerability Reduction in the Design of New Health Facilities
www.proventionconsortium.org/?pageid=37

The ProVention Consortium offers several publications on development and risk reduction.

Costing Asset Protection: An All Hazards Guide for Transportation Agencies (CAPTA)
www.trb.org/SecurityPubs

NCHRP Report 525, Volume 15, introduces transportation owners and operators to a resource allocation approach that assists in making safety and security investments. This approach allows an executive to consider multiple modes of transportation and to assess those modes and assets that merit resource allocation above what might be available through routine capital allocation processes.

Transit Security Design Considerations
FTA-TRI-MA-26 7085-05

This document is a resource for transit agency decision makers; members of design, construction, and operations departments; security and law enforcement personnel; and consultants and contractors to develop an effective and affordable security strategy and a comprehensive plan following the completion of a threat and vulnerability assessment.

Guidelines for Managing Chemical Agent Incidents in Subway Systems
DOT-VNTSC-FTA-05-02 USDOT

This publication provides an overview of the major assets of transit systems—buses, rail vehicles, and transit infrastructure and communications—as well as a preliminary assessment of the vulnerabilities to various methods of attack inherent in each asset.

A Self-Study Course on Terrorism-Related Risk Management of Highway Infrastructure
www.trb.org/news/blurb_detail.asp?id=5002

TRB's *NCHRP Report 525*, Volume 4, provides a general background in terrorism-related risk management for highway infrastructure. The report is also designed to assist bridge and structural engineers and managers in identifying critical highway assets and their potential vulnerabilities, developing possible countermeasures to prevent or ameliorate threats to such assets, and determining the capital and operating costs of such countermeasures.

A Guide to Planning Resources on Transportation and Hazards

Chapter 6: Land Use, Development, and Natural Systems

This part of the *Informer* focuses on development patterns in urban and rural areas and the ways in which those patterns impact — both positively and negatively — disaster resilience.

Research Overview

THE LINK BETWEEN DISASTERS AND LAND USE PLANNING

During the 20th century, America experienced dramatic changes in land use patterns. Early century immigrants migrated to rapidly growing cities. Mid-century wealth created the suburbs after World War II. At the beginning of the 21st century, urban revitalization and infill development changed the face of many downtowns and inner-city neighborhoods. Each change in dominant land use patterns has had a new set of implications for the natural environment (including natural hazard events) and for interactions between humans and the environment.

Collective exposure and vulnerability to hazardous events is, in large part, determined by development patterns. Where and how we build our cities and infrastructure directly affects their resilience in a disaster. For example, development on hillsides is at greater risk of landslides. Populations on grasslands can be exposed to fires. Development in these areas can even provoke these hazards. Although some disasters are completely unstoppable, good land use policies can reduce risks by limiting development in hazard-prone areas. Careful land use decisions can reduce vulnerability by assuring that development standards adequately reflect a realistic understanding of risk. Ultimately, careful land use planning reduces social, economic, and physical damage.

Many cities and regions have developed policy frameworks, political capital, and staff knowledge. They have also put other resources in place to conduct comprehensive planning activities. A comprehensive plan will note the connections among systems, including a public outreach component. This makes it a particularly appropriate method for developing and implementing vulnerability reducing activities. Burby et al. (2000) note four benefits stemming from a comprehensive planning process that includes hazard mitigation:

- Plan making is a practical way to facilitate consensus building, dispense information, and resolve conflict;
- The plan coordinates community agendas and can reduce uncoordinated and redundant actions, saving time and money;
- The plan builds a clear bridge between public interest and implementation activities;
- The plan articulates land use policy to guide public officials, private developers, and individuals in their choices and decisions.

THE LAND USE-TRANSPORTATION-DISASTER CONNECTION

Transportation priorities and investments directly affect land use patterns. Transit corridors spur multi-use development because both businesses and individuals want to locate in well-connected areas. Widening roads into and out of urban areas facilitates commuting, often leading to dispersed development. Since land use and development patterns are key indicators of community resilience in the face of disaster, strategic transportation choices can either reduce risk or increase both exposure to and the likelihood of disasters. Transportation planners are major stakeholders in the national disaster management discussion. Coordinating transportation and land use planning will ensure that their implementation creates synergistic benefits that reduce overall system vulnerability.

Most land use patterns have some weaknesses in emergency situations. For example, suburban land use patterns that require people to commute by car to work in central city areas complicate evacuation situations by separating families when disasters occur during the workday. But urban densities also create difficult disaster scenarios because more people are located in the path of the disaster when it strikes. At the same time, the growth of many suburbs to include office and industrial parks means that many people are commuting between suburbs rather than into a downtown retail core. This diffuse pattern of job/living distribution can dilute emergency response and rescue, as well as complicate evacuation.

The real issue is the coordination and integration of land use and transportation plans that appropriately account for all-hazard emergency planning. A systems approach includes evaluation of response capabilities and limitations; loss and risk reduction (e.g., mitigation); continuity of operations; and recovery strategies for all potential interruptions of service and/or disasters. Policies that combine land use design with transportation system planning can mitigate loss by linking hazard mitigation to environmental, social, and economic goals. An integrated approach to land use, development, and transportation will increase a community's resiliency, shortening response and recovery time and costs. In fact, leaders in the

> The real issue is the coordination and integration of land use and transportation plans that appropriately account for all-hazard emergency planning.

hazards field have stated: "No single approach to bringing sustainable hazard mitigation into existence shows more promise at this time than increased use of sound and equitable land use management" (Mileti 1999).

DENSITY CONTROLS AND HAZARD PLANS

One style of land use policy is urban containment. Planners and officials use growth boundaries, green belts, and limits to utility and infrastructure extensions as tools to manage development.

Containment policies have inspired debate about their ability to effectively mitigate hazards.

From one point of view, urban density is cast as an exacerbating factor of vulnerability. The 1991 Oakland Hills firestorm (which burned over 3,250 homes), the potential spread of contagious diseases such as SARS and avian flu, and the inappropriately long time required to organize a response and recovery effort in New Orleans in 2005 raise valid questions about the delivery of sufficient emergency services to large, concentrated populations.

On the other side of density is dispersed development: sprawl. Platt (2008) notes that, the "harmful impacts of sprawl in terms of air and water pollution, waste of energy and time, traffic congestion and highway accidents, lack of affordable housing, increased flooding, and loss of biodiversity have been widely documented." So sprawl is not conducive to efficient functioning of the transportation system. It can even be counterproductive.

But sprawl would not exist without a history of transportation investments and policies that favored dispersal of the population.

Now that the real and long-term effects of sprawl are clearer, transportation priorities should account for those costs and adjust accordingly.

Density is a fact of life. While densely populated areas pose a range of challenges beyond hazards, they also provide many advantages. Dense development may be a more cost-effective use of public resources on a per capita basis, freeing resources for maintenance, renewal, and replacement of existing infrastructure systems, which increases resiliency.

Compact urban forms also reduce the amount of dispersed development potentially in the path of a disaster. Denser development brings economic actors closer together, facilitating communication in preparedness, response, and recovery operations. Compact development also decreases vulnerability, concentrating the population needing services in an accessible area.

Hazard Planning as a Land Use Planning Goal in Oregon

Since 1973, Oregon has used 19 statewide planning goals to guide comprehensive planning. Each city and county is required to adopt a plan that incorporates all of the goals and to pass the necessary ordinances for implementation. Local comprehensive plans must incorporate all the goals, creating an integrated, comprehensive set of policies. Goal seven deals with "areas subject to natural hazards" and mandates that "local governments reduce risk to people and property from natural hazards." Evaluations of risk in accordance with goal seven are based on:

- The frequency, severity, and location of hazards;
- The effects of the hazard on existing development;
- The potential for development in the hazard area to increase the frequency and severity of the hazard; and
- The types and intensities of land uses to be allowed in the hazard area.

After citizen review and comment on the results, jurisdictions are directed to "adopt or amend, as necessary … plan policies and implementing measures consistent with the following principles: A) avoiding development in hazard areas where the risk to people and property cannot be mitigated; and B) prohibiting the siting of essential facilities, major structures, hazardous facilities and special occupancy structures … in identified hazard areas."

These implementing measures are necessarily coordinated with Goal twelve, which guides transportation planning to create "safe, convenient, and economic transportation systems." Tying in with hazard mitigation, transportation plans are mandated to consider social consequences, incorporate multiple modes, and "minimize adverse social, economic and environmental impacts and costs." The Oregon Department of Land Conservation and Development reviews all comprehensive plans for compliance.

Source: Oregon Department of Land Conservation and Development 2008. www.oregon.gov/LCD/goals.shtml

Low-Impact Development

One way to mitigate the impact of the built environment on the natural environment is through low-impact development (LID). The term low-impact development encompasses a variety of stormwater management techniques including bioswales, rain gardens, green streets, and pervious pavers.

LID can help minimize the number of sewer overflow events that cause flooding as well as reduce the volume of contaminated flows by managing more stormwater on site and keeping flows out of sewer pipes.

The U.S. EPA estimates the costs of controlling combined sewer overflows throughout the country at approximately $56 billion. Developing and implementing stormwater management programs and urban runoff controls will cost an additional $11 billion to $22 billion (Kloss and Calarusse 2006).

Though it varies from site to site, generally LID controls can be more cost effective and have lower maintenance costs than conventional stormwater controls. In some cases, LID can help lower construction costs by making use of a site's existing or undisturbed drainage conditions in ways that conventional controls cannot.

Not only can pervious pavement replace conventional road building techniques at a lower cost, but LID techniques that retain more stormwater on site and reduce flooding could generate avoided costs for construction, such as road culverts.

The precise benefit-cost comparisons and appropriate LID techniques should be tailored to local conditions, but LID is already proving to be an industry best practice.

Ultimately, researchers have found no significant differences between vulnerability induced by explicit sprawl containment policies (urban growth boundaries) and implicit ones (natural boundary features).

Researchers have concluded that comprehensive hazard mitigation planning is key to decreasing vulnerability within urban boundaries: "Plans should consider how containment will affect development pressures in hazardous areas, identify a range of measures for coping with increased vulnerability and determine the costs of these measures and the institutional capacity to carry out a comprehensive hazard program" (Burby et al. 2001).

THE IMPORTANCE OF CONNECTIVITY

One mitigation principle that can be incorporated into a land use and transportation plan is connectivity, or the directness and density of links in a transportation network. A high level of connectivity decreases travel time and distances to provide more travel routes allowing for the most direct course. Characterized by many links between roadways or paths, connectivity creates a more accessible, resilient transportation system.

Good land use and transportation design will ensure connectivity of the system so that the flow of goods, services, and people (in essence, the economy) will continue to function during a disaster. A transportation system with a high level of connectivity will allow citizens to leave, and emergency personnel to enter, affected areas quickly. Aid can be received by and administered to those who need it most.

In areas that are especially disaster- prone, sufficient escape routes must be maintained so that bottlenecks do not occur. For example, connectivity provides multiple entrances and exits to a neighborhood and various modes by which freight can enter a city. Redundancy ensures that if one exit or mode is damaged or blocked, another option is available. In this way, incorporating connectivity and redundancy into land use and transportation planning is a preparedness and mitigation strategy.

LOCATION OF DEVELOPMENT

Another mitigation strategy that can greatly reduce vulnerability is the creation of regulations or strong incentives to direct development away from hazard-prone areas. Incentives can be used at any stage of development—before plans have been made or as the post-disaster rebuilding begins.

If development of a hazard-prone area is inevitable, providing clear building, zoning, and density regulations or policies will direct sustainable growth. Incentives can also effectively encourage development to incorporate hazard preparedness—tax abatements or density and mitigation bonuses can change the course of risky development and land use. Additionally, retrofitting existing development to fully comply with regulations may prove to be expensive and inspire more resilient development (Burby et al. 2000).

Leveraging existing regulations that apply to other, special kinds of land can also prevent development in a hazard-prone area. Designating the space a park, wildlife refuge, or as significant for watershed health does not require jurisdictions to create a new set of regulations, yet achieves a mitigation goal. Vulnerable development will also decline if the federal government begins to shift responsibility for restoration more to local jurisdictions, developers, and homeowners.

For example, though controversial, governments can withdraw subsidies for and aid to development that con-

tinues even under unacceptable levels of risk (Godschalk 2003).

ENVIRONMENTAL IMPACT

There is growing acceptance of the connection among land use, transportation patterns, and environmental impact, and of the connection between environmental impact and natural hazard frequency. Land use plans that reduce resource consumption and the degree to which natural systems are altered function to reduce hazard vulnerability and improve community resilience.

In 2001 the Environmental Protection Agency released a report titled *Our Built and Natural Environments*, that investigated the direct and indirect impacts of the built environment on the natural environment. The report concluded:

> Urban form directly affects habitat, ecosystems, endangered species, and water quality through land consumption, habitat fragmentation, and replacement of natural cover with impervious surfaces. Development patterns and practices also indirectly affect environmental quality since urban form influences travel decisions that people make. Certain patterns of development encourage increased use of motor vehicles, which is associated with growth in emissions of air pollutants and the greenhouse gases that contribute to global climate change. Air pollution and climate change, in turn, can adversely affect water quality and habitat (U.S. EPA 2001).

A clear example of the connection between land use and environmental impact is impervious surfaces. Sprawling commercial and residential development necessitates parking lots, rooftops, and sidewalks that do not allow water to pass through. Instead they channel stormwater and natural runoff into limited areas. Sewers, creeks, and rivers have finite capacity. When they are overwhelmed, flooding occurs. Impervious surfaces also channel pollutants and toxins directly into sewers, streams, and rivers. They have been shown to increase the likelihood of flash flooding.

The Federal Highway Administration of the U.S. DOT reports that impervious surfaces can create more than five times as much runoff than natural ground cover (Federal Highway Administration 2008). More dense development, especially when coupled with effective and environmentally aware stormwater management practices, can dramatically reduce the amount of impervious surface needed to support our population.

TOOLS FOR PLANNERS

There are many tools available to planners and officials to implement mitigation strategies. When possible, strategies, codes, and procedures should be in place prior to development. A comprehensive set of policies which includes hazard mitigation ensures that, as choices are made about where and how to build and grow, complete information is available about local hazards and what it will take to minimize vulnerability.

FEMA's 1998 report *Planning for Post-Disaster Recovery and Reconstruction* lists six questions that can help evaluate policies and regulations (Schwab et al. 1998). Does the plan:

- Recognize the existence of different hazard areas that are subject to different forces?
- Cover all types of structures (single-family, multi-family, commercial, etc.)?
- Apply to public facilities as well as private?
- Encourage higher-density uses to locate outside the most hazardous area?
- Result in nonconforming uses and structures being brought into conformity after they are damaged?
- Relate the level of development in the community to the capacity of existing evacuation routes and the time it would take to evacuate those areas?

WHAT DOES THE RESEARCH IMPLY FOR TRANSPORTATION PLANNING?

The built environment has an indelible impact on the natural environment. When transportation, land use, and hazard planners engage in a comprehensive planning process, resources for disaster preparedness and mitigation are leveraged more effectively.

The backlog of deferred transportation maintenance highlights the vulnerability of the nation's transportation systems and mandates that every investment work toward increasing the security and resiliency of the system. Coordinated transportation, land use, and hazards planning processes that advocate for compact urban development will create connectivity and redundancy, reduce environmental effects of new infrastructure, and help to achieve resiliency.

A Guide to Planning Resources on Transportation and Hazards

Useful Resources and Documents

Planning for the Unexpected: Land Use Development and Risk
www.planning.org/APAStore/

The American Planning Association's *Planning for the Unexpected* helps planners identify and manage risks associated with land use. The book can be ordered on the APA website.

Planning for Natural Hazards: Oregon Technical Resource Guide
www.oregonshowcase.org/projects/resourceguide

The Partnership for Disaster Resilience offers technical resources guides (TRGs) for Oregon cities and counties to limit the effects of threats from natural hazards. Targeted at local staff and officials, TRGs are guides and evaluation tools designed to help jurisdictions in developing policies, plans, and non-regulatory mitigation strategies to prevent high-risk development.

Environmental Expert
management.environmental-expert.com/index.aspx?level=5&

This site provides resources on law, natural protection, insurance, finance, and planning and design.

The Transportation/Land Use Connection (APA)
www.planning.org/APAStore/Search/Default.aspx?p=3675

This report examines the need for public sector investment in land use and transportation development and the tools and techniques planners can use to integrate transportation and land use. It looks at the forces shaping cities and their transportation systems, frameworks for evaluating transportation and land use policies, and the role of regional comprehensive plans.

FEMA and Mitigation Planning
www.fema.gov/plan/mitplanning/index.shtm

Here FEMA provides resources on policies, activities, and tools to implement mitigation actions.

IBHS/APA Summary of State Land Use Planning Laws
www.ibhs.org/publications/view.asp?id=302

This report by the Institute for Business and Home Safety and the American Planning Association asks detailed and specific questions about mandatory hazard mitigation elements in local comprehensive plans focusing on statutes and technical elements.

National Response Framework Resource Center
www.fema.gov/emergency/nrf/

FEMA's site offers overviews and further information about the National Response Framework (NRF), National Incident Management System (NIMS), Stafford Act support, and training resources.

Chapter 7: From Theory to Practice: Case Studies

Case Study 1: The PortSTEP Program: Integrating and Coordinating Port Security in a Multimodal Transportation System

PORTS IN CONTEXT

The port environment is unique among transportation systems because its primary goal is to connect one mode of transportation to another, rather than one destination to another. Rail and truck services bring goods that are taken on by ships, and ferries and airplanes transport people who access mass transit or road systems. Over 95 percent of trade overseas passes through public ports (U.S. Congress 2002). More than 90 million containers continue on from United States ports in trucks and railcars to their final destination. As a gateway for these modal connections, ports must sustain the natural movement of goods and people as they progress into, through, and out of the port. This reality necessitates a broad multimodal, regional, and interagency view of port security.

The Transportation Security Administration (TSA) manages security for most transportation sectors, including aviation, pipelines, and freight and passenger rail. However, the U.S. Coast Guard (USCG) coordinates port security and maritime issues. Despite functional overlaps in the port environment, there is no history of continuously coordinated security efforts. In 2003, the creation of the Department of Homeland Security incorporated both agencies thereby increasing the opportunity for coordination and communication of security efforts.

PortSTEP (Port Security Training Exercise Program) was a program jointly created and operated by the TSA and USCG that, between 2005 and 2007, executed 40 port security drills. This case study discusses the lessons learned from the PortSTEP program to highlight how increased multimodal and interagency coordination of planning and preparedness efforts will advance the goals of comprehensive port security specifically, and transportation security in general. It also describes some continuing challenges facing port and transportation security.

PORTSTEP: IMPROVING COLLABORATION AND COORDINATION THROUGH WORKING RELATIONSHIPS

Since the terrorist attacks of 2001, a series of overlapping and multifaceted acts of legislation, presidential directives, plans, and programs have been enacted to better assess, organize, and secure vital infrastructure in the United States. At each level, and with each new update, this "family" of plans works toward comprehensive and seamless mitigation, protection, preparation, response, and recovery efforts for human-induced and natural hazards affecting national infrastructure.

Though designed to enhance coordination and collaboration, the web of plans and procedures has not always been supported with funding for implementation and training. Commander Richard Gaudiosi, USCG (ret.), was part of building and delivering the PortSTEP exercises. He observed that, prior to the program, some port personnel were not aware of the many local and federal

Federal Regulations in the Maritime Environment

Federal plans pertinent to port security include:

2002 MARITIME TRANSPORTATION SECURITY ACT (MTSA). The MTSA allocated $20 million to the TSA to take a comprehensive approach to port security through training exercises that increase security capabilities and develop and disseminate best practices. By doing so, the MTSA recognized ports as a multimodal environment and addressed interagency coordination.

NATIONAL INCIDENT MANAGEMENT SYSTEM (NIMS). In 2004, the NIMS set forth an organizational framework by which resources necessary for managing a hazardous event were identified, coordinated, and deployed.

NATIONAL SECURITY PRESIDENTIAL DIRECTIVE 41/HOMELAND SECURITY PRESIDENTIAL DIRECTIVE 13 (NSPD 41/HSPD 13): The National Strategy for Maritime Security and its supporting plans are a multi-agency effort encompassing outreach and awareness, recovery, supply chain, policy coordinating committees and action working groups, and international coordination issues.

NATIONAL INFRASTRUCTURE PROTECTION PLAN (NIPP). NIPP requires federal departments to identify, prioritize, and plan to protect "critical infrastructure and key resources." It is supported by 18 sector-specific plans that detail a risk management framework and strategy as well as discuss resources, roles, and responsibilities in the context of each specific sector.

A Guide to Planning Resources on Transportation and Hazards

plans that apply to port security. Restricted access further complicated plan implementation.

PortSTEP was one of a series of programs designed to identify gaps in communication and information sharing, technology implementation, and coordination. Developed in partnership between the TSA and the Coast Guard, it operated a series of exercises to test federal, state, and local responses to specific security events. Between 2005 and 2007, PortSTEP executed security drills at 40 ports across the mainland United States that engaged the emergency response plans built by the Area Maritime Security Committees (AMSCs). AMSCs are chaired by the USCG representative and incorporate federal, state, and local governments, public safety and emergency management, maritime industry representatives, and other port stakeholders. Broadly, the objective of PortSTEP was to strengthen "the nation's ability to prevent, respond to, and recover from a transportation security incident in a port and maritime environment."

PortSTEP engaged not only AMSC members, but also a broad range of stakeholders associated with the port in discussion-based tabletop and functional exercises. Participants ranging from FEMA representatives to local law enforcement worked through human-induced hazard scenarios asking the fundamental and complex questions that face ports as a critical yet vulnerable infrastructure node. The tabletop drills were modeled as real-time events, with participants receiving intelligence injects from multiple sources concerning the entirety of the intermodal maritime environment. The PortSTEP drills successfully emphasized the interconnected and interdependent relationship between maritime and surface transportation response and reaction.

Commander Gaudiosi said PortSTEP was not only a venue to disseminate best practices but that the program also helped to create new relationships and strengthen existing ones. It provided a framework for conversations among the Coast Guard, local law enforcement, rail operators, and customs agents who have roles and responsibilities for intelligence gathering, distribution, response, and recovery following a transportation security incident. Gaudiosi also applauded the participation of industry in the PortSTEP exercises as not only users of the port environment and corresponding surface transportation, but also as foundations of response and recovery in terms of immediate supplies (e.g., water) and long-term economic recovery (e.g., continued shipping and job stability).

Over the course of the program, an estimated 2,500 stakeholders took part in the PortSTEP program and helped to identify gaps in planning, vulnerabilities of the physical port environment, opportunities to strengthen communication, and strategies to clarify responsibilities. PortSTEP was a valuable investigation of ports as complex nodes of intermodal transportation assets and infrastructure.

Definitions

COMMUNICATION: Ability to share information about plans and actions in a way to facilitate collaboration and coordination.

COORDINATION: Consistent actions among programs/departments/organizations such that the work in one area does not counteract work in another area. In the best case, security activities in one area support/increase security in another area. Differing regulations do not preclude coordination.

COLLABORATION: Joint efforts to increase security overall providing cost-effective use of resources.

LESSONS LEARNED

The PortSTEP program identified three main weaknesses in the U.S. port security system (Clarkson and Gaudiosi 2007):

Information sharing in the unified command structure was non-existent or ineffective in most exercises.

- This issue stems from some major challenges facing security organizations, including inaccessible information (e.g., classified material), heavy use of jargon or industry/agency specific language, and the lack of awareness of who should receive information or whether it should be shared at all.

Awareness of Incident Command Structure/National Incident Management System concepts was low, rarely expanding beyond basic understanding and seldom including training on specifics.

- Some parts of the framework have been updated since its original publication or are updated regularly. Training on these updates is not always a priority because of funding and time constraints.

Awareness among all agencies, commercial entities, and service providers of the guidance and content in Area Maritime Security Plans was low.

- Area Maritime Security Plans address local and regional issues but sometimes cannot be disseminated to, and therefore used by, port-related commercial entities or service providers because of confidentiality. Additionally, non-port personnel may be less able to understand procedures or policy implications. Programs like PortSTEP that reach out to key stakeholders will bridge this gap.

PortSTEP made significant progress in broadening the concept of port security. It proved to security and transportation professionals that increased coordination of plans and collaboration between transportation modes is urgently needed to identify and address security gaps. From his observations as a program provider, Commander Gaudiosi noted that PortSTEP revealed especially

the poor condition of regional coordination. Intermodal transportation is critical for moving goods from the port to markets. If one port is shut down for any reason, other regional ports should be prepared to support its function to keep a regional economy from failing.

As a result of the program, membership in the Area Maritime Security Committees is expanding to encompass more modes of transportation with the goal of: 1) facilitating relationships between maritime and surface transportation sectors; 2) planning more effectively, using resources more efficiently, and applying expertise better; and 3) reducing redundancy, duplication of efforts, and counterproductive activities.

NEXT STEPS AND CHALLENGES IN PORT SECURITY

While PortSTEP has been an important first step in better coordinating planning and preparedness efforts of ports with other transportation modes, there is still much work to be done. Federal planners and transportation and security professionals interviewed for this case study agree that the major challenges include the need to increase coordination regionally among ports, find funding to support training and planning efforts, and integrate new technology.

INCREASING REGIONAL COORDINATION

Intermodal programs and regional initiatives are now underway to increase the resilience of local, multimodal transportation systems. ISTEP, the Intermodal Security Training Exercise Program, evolved from PortSTEP and continues with the goal of increasing awareness of security protocol as well as explicitly engaging a wide range of stakeholders from transportation and related sectors.

Gaudiosi cited exercises that have taken place under the auspices of ISTEP focusing on freight rail, mass transit, commuter rail, and the combination of freight and passenger rail as proof of the shift away from a modally based security concept overall. He credits the PortSTEP programs with the impetus behind that evolution: "In order to understand the security issue, you have to look at it from a regional level to get a better handle on where the issues are and how to address them."

The regional exercises of ISTEP challenge participants to consider the impact on one form of transportation or one location if others experienced a transportation security incident: e.g., what is the demand on nearby ports if one is attacked or becomes unsafe? Lessons learned from this process will be issued in 2009 and should point to specific steps that can be taken to increase regional coordination.

FUNDING

Having worked at many levels of the transportation and security sectors, Mike Fischer, former Director of Security for the Port of Baltimore and current Homeland Security Advisor to the Maryland Secretary of Transportation, has a deep understanding of the evolution of both fields over the last few decades and the challenges and opportunities on the horizon. Many jurisdictions are financially strained when it comes to implementing technology upgrades, personnel training, or even the routine maintenance required to achieve the highest level of security. Facing the required 25-percent local match for port security grants, Fischer is studying the economic impact of deferred security advancements in Maryland.

PREPARING FOR INTERMODAL TRANSPORTATION

Another pending challenge to transportation security overlaps with funding concerns: multimodal planning and cross-agency training. Changing demographics, travel patterns, fuel costs, density, and technology all influence transportation decisions and options for people and goods. While the specific threats of the future are uncertain, it is known that the intermodal mobility of people and goods requires holistic security planning.

Transportation planners and security professionals must overcome wasteful system redundancies and counterproductive programs or policies to provide safe passage in all modes. As users diversify their transportation modes, the threats diversify as well. Collaborative service provision and security efforts are crucial to achieving

Tips for Evaluating Transportation Risk

The *Transportation Systems Sector-Specific Plan* (one of 18 composing the NIPP) delineates two ways to assess the risk faced by the transportation system and its component parts.

"Risk views" are four "distinct and complementary ways of evaluating transportation infrastructure and defining transportation systems." They are modal, geographic, functional, and ownership categories illustrating how risk manifests and is managed by the transportation system.

These risk views are transected by three risk layers: physical, process, and institutional. These describe the type of threat to the transportation system.

This approach to risk assessment encourages interagency collaboration and a multimodal approach.

hazard-resistant and resilient transportation systems. As described above, the recent lessons learned in the port environment are a prime example of how an expanded view of security reveals not only vulnerabilities but also ways to protect key infrastructure systems. Further, it is necessary to include advocates for vulnerable populations and human services providers in discussions of transportation risk assessment.

TRANSPORTATION ASSET OWNERSHIP

One challenge to better intermodal coordination is the diverse ownership models currently employed to provide transportation services, from regulated and unregulated private companies, federal services, locally owned assets, and a wide array of public-private partnerships. Private bus companies, deregulated but underwritten airlines, and private train companies that use publicly owned rights-of-way each present a different security challenge. These entities may be subject to security regulations in varying degrees, but the coordination of their plans, training, and services will, in the event of a disaster, be critical for efficient response and recovery.

CONCLUSION

U.S. ports conduct goods and people in their travels to and from the domestic and international economic marketplace. Surrounding the port and supporting its operations is a multimodal transportation web that reaches beyond the port itself and serves regional and national transportation needs.

Coordination and communication across transportation modes is critical and, as PortSTEP participants and evaluators have learned, needs to encompass not just people who work with port security, but also those who understand the transportation system as a whole.

Lessons learned from PortSTEP can be applied to other aspects of the transportation system; to achieve multimodal transportation security, efforts to include a wide range of stakeholders must continue through education and training around existing plans and procedures.

A valuable benefit of this type of training exercise is the networks it develops among port, security, industry, and transportation representatives. Programs such as PortSTEP serve as a model not just for port security, but for comprehensive, system-wide transportation security in general.

Incident Management and Command: NIMS and ICS

The National Incident Management System (NIMS) is a standardized approach to the incident management process including command structures, preparedness activities, resource management, and communications and information management. According to Homeland Security Presidential Directive—5, implementing this comprehensive framework enables "federal, state, and local governments to work effectively and efficiently together to prepare for, respond to, and recover from domestic incidents, regardless of cause, size, or complexity … (by standardizing) a core set of concepts, principles, terminology, and technologies covering the incident command system; multiagency coordination systems; unified command; training; identification and management of resources (including systems for classifying types of resources); qualifications and certification; and the collection, tracking, and reporting of incident information and incident resources."

One aspect of NIMS, the Incident Command System (ICS), is an on-scene, tactical-level tool used for the command, control, and coordination of response to all major incidents. This protocol facilitates joint, multiagency, or cross-jurisdictional operations by allowing responders to adopt an integrated organizational structure appropriate in size, complexity, and scope to meet the demands of the incident. ICS may include five functional areas including operations, planning, logistics, finance/administration, and intelligence.

The strength of ICS is rooted in the flexibility of the functional areas to expand or contract in real time. Police supervision, medical response, and/or debris removal following a two-car accident will not usually require multiple jurisdictions or emergency service providers to interact in a significant way. On the other hand, a train derailment causing harm to passengers or spilling toxins will require the response of a range of agencies, departments, organizations, and individuals. Treating related injuries at multiple medical facilities, re-routing other rail traffic, disseminating critical information about health and travel issues, apprehending suspects, and ensuring safe clean up of debris can be effectively and efficiently accomplished through a unified command, as established by ICS. The unified command hierarchy provides for and assures coordinated objectives, strategies, plans, priorities, and communications so that no aspect of response acts counterproductively to others and resources are used most efficiently.

The DHS provides numerous resources, from grants to training opportunities, to assist jurisdictions in institutionalizing and implementing the components of the NIMS process. Released in 2004, the final national comment period for NIMS closed on May 30, 2008. Visit **www.fema.gov/emergency/nims** for updates.

Sources: "Simplified Guide to the Incident Command System for Transportation Professionals," USDOT, Federal Highway Administration, February 2006; **www.NIMSonline.com**, accessed August 6, 2008; National Incident Management System, USDHS, March 1, 2004.

Case Study 2: Evacuation and Fires in Southern California

Evacuations challenge the capacity, flexibility, and integrity of the transportation system. They are a keystone test of its resilience. Different types and scales of hazard events engage evacuation as a tool in varying ways. A neighborhood might be evacuated in advance of a passing toxic shipment or a region might evacuate in anticipation of a hurricane. Evacuations might also be necessary after an event such as an earthquake or terrorist attack when further damage could occur from aftershocks or building instability.

In the wildland-urban interface—the area where residential and wildlands meet and mix—fires pose the greatest threat. Not only are weather and fuel conditions leading to more frequent and intense fires, but more people than ever before live in fire-prone areas. Increasing density in the wildland-urban interface area has not been matched with equal investment in infrastructure (e.g., roads to provide multiple access routes) or fire-safe community design (e.g., construction, landscaping, spacing between structures). Every fire season, communities in the wildland-urban interface area are forced to evacuate.

This case study will describe the unique preparedness measures and response strategies required by a fire hazard.

Rather than focusing on a single program or evacuation, this case study examines several approaches to improving evacuation procedures, providing specific examples of solutions to the challenges described in other parts of this *Informer*. It provides ideas about:

- How coordination and communication of data among agencies and partners can improve the evacuation process;
- How land use planning can increase community resilience and facilitate evacuation;
- How vulnerable populations can be factored into evacuation plans.

In a fire, how and when information is collected and distributed affects the public's response and the ability of emergency response professionals to protect lives and combat the blaze. This section highlights some cutting-edge approaches to information sharing.

INTERAGENCY COLLABORATION EXPANDS AVAILABLE DATA

In a typical fire, responding agencies draw from many data sources to make decisions about resource allocation, public health, and evacuation. Creating a better infrastructure for gathering and sharing that data will allow for more rapid notification of evacuations and will improve the accuracy of evacuation decision making. One example of this type of collaboration for improving fire information is the seven-year technology demonstration program funded by NASA to test the ability, and practical use, of a remote, airborne, unmanned sensing vehicle to gather fire information.

Meeting the data needs of the fire community is Vincent Ambrosia's job. Working from NASA's Ames Research Center at Moffett Field, California, Ambrosia is part of a team that has built a successful method for gathering and distributing real-time fire information. Thanks to the program, incident commanders at the 2007 fire complexes in San Diego County could access data only 5 to 10 minutes after it was gathered, a great improvement over the 6- to 12-hour information delay common with traditional methods.

NASA's technology demonstration program, which includes training for incident commanders on how to interpret data, is an example of how interagency collaboration between federal and local partners is improving disaster response capability.

COMMUNICATION: TIMING AND TECHNOLOGY

Fires are extremely volatile and can move quickly across fuel-rich landscapes. Because a slight change in the wind can significantly alter the fire path, timing is everything. Providing residents with as much advance notice as possible allows them to move to safety at a pace that does not overwhelm transportation infrastructure.

San Bernardino National Forest Fire Chief and National Incident Commander Mike Dietrich serves the

Meeting Real-Time Data Needs

Vincent Ambrosia remembers how, as the 2007 Santiago Fire in Orange County, California, swept closer to a populated urban area, the fire and public safety responders struggled with old data about their fire front because smoky conditions prevented traditional data gathering methods. Aware that the remote sensing flights were underway for the fires to their south, the Santiago responders requested a flight by the NASA vehicle.

FAA regulations restrict unmanned flights over areas with certain levels of density, but the NASA team worked with the FAA to approve the emergency flight mission and was able to display real-time data about the Santiago fire front. That experience proved that the NASA program data delivery capabilities are ready to be transitioned to local use. It is the type of tool that they need.

fire-prone mountain communities in San Bernardino and Riverside County. In his experience, the timing of information is crucial when coordinating an evacuation of hard-to-access and isolated communities. Unnecessary evacuations in one fire season can dampen public responsiveness in the next, so Dietrich strives to work with front line responders, sheriffs, and the local Office of Emergency Services to set accurate, phased evacuation orders: immediate; 4 to 6 hours in advance; and 24 hours/potential fire threat. Law enforcement and first responders notify the most threatened areas by going door-to-door; TV, radio, and reverse 911 are also engaged as methods to alert people to the approaching threat. San Diego County has an additional approach: they implemented an opt-in, online registration system for those wanting to receive evacuation notices via cell phone text messaging.

UNIFIED COMMAND

Gathering the data is a critical first step, but how the incident command structure processes that information and translates it into action is just as important. In response to a fire incident, San Bernardino and Riverside counties activate a command structure that is a model for how to effectively implement real-time information about fire conditions. The Mountain Area Safety Taskforce (*MAST, see sidebar, page 31*) established protocols for its counties whereby a unified command structure that includes the sheriff's department is created from the beginning of any fire incident.

As a national incident commander, Mike Dietrich has participated in the response to many large-scale disasters, including Hurricane Katrina and many seasons of fires in Southern California. When working close to home in San Bernardino or Riverside County, he knows that sheriffs and others responsible for evacuations and public safety are fully integrated under the incident commander, who holds primary jurisdiction over fire response. Under a unified command structure, there is consistent, two-way communication. Evacuation decisions are made in the context of complete, up-to-date fire information. Law enforcement personnel managing the evacuation are in constant contact with the incident commander, who continuously coordinates the progress of the evacuation with fire information.

When dispatched further afield, to other counties or states, Dietrich is often "amazed that law enforcement is separate from fire." He finds it "essential for them to be at the same post. It greatly aids in communication and is easier to meet public information needs." In large-scale hazard events, national incident commanders from around the country participate in the response effort. The MAST model for unified command could serve to facilitate relationship building in the event that incident commanders are not familiar with the disaster area.

Watching not only data collection but also local use of that data expand in recent years, Ambrosia is sure "the possibilities for integration of data are endless." It is clear that accurate, real-time information supports efficient fire management, resource allocation, communication, and evacuation decisions.

LESSONS LEARNED SUMMARY: COMMUNICATION, COLLABORATION, AND COMMAND

Communities in Southern California have learned that evacuations run more smoothly if:

- Real-time data support resource allocation decisions;
- Emergency and transportation planners have anticipated the potential capacity of the transportation system;

Collaborative Evacuation Modeling

Evacuations present an opportunity to use infrastructure in a new way. Even though the physical systems remain the same, planners and responders must account for new demand horizons, route preferences, and travel times under evacuation scenarios. As cross-jurisdictional participation in evacuations grows, so does the need for a comprehensive evacuation modeling tool. Partnerships among emergency preparedness groups, transportation planners, and academic institutions are not only producing assessments of regional transportation systems but also widely applicable models.

Modeling tools at the frontier of the field are expanding to incorporate ever more complex inputs. Including weather forecasts as a dynamic piece of data allows the evacuation model to anticipate and increase or decrease in an evacuation area, or even predict whether a route believed safe could be threatened by the changing course of a fire or hurricane. As variable as the weather, human behavior in an evacuation scenario is the crux of any transportation or evacuation model; who will use the system, when, where and for what? To anticipate the needs of a population during an evacuation, Thomas Cova, Director of the Center for Natural and Technological Hazards at the University of Utah, cites evacuation exercises and drills as a way to help transportation/evacuation planners and emergency responders visualize scenarios and fortify models with data about demographics, evacuee participation, and low-mobility populations.

- Possible system weaknesses are addressed through strategic evacuation techniques such as phasing and contra-flow;
- Notification of evacuation orders reaches residents through fast and effective methods; and
- The incident command structure incorporates multiple aspects of response, including fire response, public safety, and medical operations.

LAND USE MATTERS: PREPARE-STAY-AND-DEFEND

Evacuation notices are given to protect lives. When asked to evacuate, residents have two options: evacuate to a shelter or another safe location, or stay. In the case of isolated communities, traveling to a shelter may be too risky. Most civilian deaths from wildfires come in the process of evacuating. Also, as population in the wildland-urban interface grows, transportation infrastructure does not always keep pace to support an evacuation. (Cova 2005).

This section of the case study will briefly discuss how land use patterns and homeowner actions before, during, and immediately after a fire can create defensible space and protect the structure; this tactic is called "shelter-in-place" or "prepare-stay-and-defend."

Thomas Cova, Director of the Center for Natural and Technological Hazards at the University of Utah, has spent his career studying evacuations. Cova has documented a worrying trend: continued development in the wildland-urban interface brings higher densities but not always commensurate upgrades to road conditions and capacity.

With a small number of winding, single-lane roads available even during perfect conditions, mountain communities understand that warning might not come in time for a safe evacuation of all residents. Isolated communities are "pushed into a place where shelter-in-place becomes an important reality."

Municipalities are beginning to recognize the utility of defensible space and support it through language in zoning and development code. In 2005, California extended its law requiring defensible space around a home, mandating clearance of fire fuels for 100 feet around a home for most grass-, brush-, and timber-covered private land. The previous law had required only a 30-foot perimeter.

If instituted in concert with other mitigation strategies, Cova (2005) speculates that "prepare-stay-and-defend" can have rippling benefits: "From a land use and transportation point of view, we can reduce travel demand during a fire if more people stay, but then land use patterns have to create defensible structures."

Mountain Area Safety Task Force

The mountain communities inland of Los Angeles formed the Mountain Area Safety Taskforce (MAST) in 2002 as a coalition of local, state, and federal government agencies involved in fire safety. Included are private companies; volunteer organizations; and emergency service organizations including the sheriffs' departments, highway patrol, CalTrans, and county offices of emergency services; utility companies; hazardous material clean-up agencies; and various fire service organizations.

To foster public interest in fire safety, MAST routinely works with local citizen fire councils on outreach measures regarding mitigation and evacuation, providing public evacuation maps that not only indicate road condition (dirt, paved) but also the location of fire stations, schools, and hospitals. In an effort to maintain interoperability and readiness, MAST activities have expanded to include fire pre-planning, tabletop exercises for emergency responders, and the identification of communication links.

MAST is an example of how interagency collaboration not only enhances response through a unified command structure and interagency training, but also improves preparedness through public outreach.

Gathering data is a critical first step, but how the incident command structure processes that information and translates it into action is just as important. San Bernardino and Riverside counties activate a command structure in response to fire that is a model for how to effectively implement real-time information about the fire conditions.

LESSONS LEARNED SUMMARY: ALTERNATIVES TO EVACUATING

Communities in Southern California have learned creating defensible space can be a viable strategy when:

- Homeowners are able to take specific action before, during, and after a fire event;
- There may not be sufficient time for the homeowner to evacuate;
- Communities have limited, low capacity, or poorly maintained egress/ingress routes; and
- Land use patterns account for fire vulnerability, and building codes require defensible space as a strategy to protect structures.

PEOPLE MATTER: EVACUATING VULNERABLE POPULATIONS

The cover article for the July 2008 *Natural Hazards Observer* discusses the current state of mass evacuation planning. It described one area for improvement. Evacuation plans are only just beginning to account for the needs

> Evacuations are perhaps one of the most obvious ways in which the transportation system participates in the disaster cycle. These mass movements of people require transportation infrastructure to support unusually high volumes of traffic, but also to function in ways that are totally unplanned for under normal conditions.

of vulnerable populations (Wolshon 2008). As discussed earlier in this document, risk and vulnerability are not incurred evenly across populations. To protect all citizens during hazards and natural disasters, evacuation plans must address the spectrum of risk and vulnerability present in the community.

This section of the case study highlights what some Southern California communities have done to account for vulnerable populations in evacuation plans.

ISOLATED COMMUNITIES

Current development patterns increase the exposure of residents to the forces of nature in the wildland-urban interface area. For a community nestled on a hillside, the lure of the valley views and rural lifestyle may outweigh safety concerns until the reality of limited egress and ingress routes comes into sharp focus during an evacuation. Isolated communities are more vulnerable because their location makes them more likely to require evacuation and because it is more likely that evacuation routes will be cut off by the fire or will be unable to support traffic volume.

Ramona, California, has learned the importance of having consistent and coordinated local law enforcement participation in traffic management during an evacuation. Several fires reported on Sunday, October 21, 2007 led to an advisory evacuation notice to the mountain communities northeast of San Diego, California. Ramona, with its 40,000 people, was one of the first areas under mandatory evacuation orders in response to the fires. There are four roads leading in and out of this valley community, and the path of the fire left only two viable exit routes. Both westbound exits are two-lane highways, and the eastbound lane was kept open for emergency response vehicles. High levels of responsiveness to evacuation orders, limited route availability, and road conditions led to traffic jams with little to no traffic movement for hours. However, once law enforcement officers began to supervise key intersections, traffic cleared rapidly. No lives were lost in Ramona, but local responders are considering phased use of reverse 911 as well as road widening to mitigate future fire threats.

Just inland of urban San Bernardino, California, lie the mountain communities of Big Bear, which have focused efforts on outreach and education that target tourists as well as local residents. MAST engages the town's permanent residents through public outreach on current evacuation plans, but in the summer months, when fire threat is imminent, organizational camp participants and tourists increase the population and challenge evacuation notification and route capacity. The area was in the path of the 2003 Old Fire and executed a successful evacuation of 100,000 people, instituting a phased evacuation to avoid overwhelming the already constrained roads down from the mountain. In 2007, the three access roads again sustained the evacuation of 35,000 people over only eight hours, in advance of the Grass Valley and Slide fires.

LIMITED MOBILITY POPULATIONS

Limited mobility populations are those groups of people that cannot independently respond quickly, if at all, to evacuation notices. This may come about because they lack private transportation options or have additional needs that cannot easily be met if they do evacuate. These groups incur more intense hazard vulnerability because they rely on systems that could be directly affected by the hazard. To ensure the safety of limited mobility populations, evacuation plans must anticipate these complications.

In 2007, the Witch Creek fire threatened the towns of Escondido, Rancho Bernardo, and Poway, requiring fire officials and staff at area hospitals to evaluate patient needs and resources in anticipation of an evacuation notice. The evacuations took place with the help of school buses and ambulances and were considered a successful application of the new evacuation plans and lessons learned: after the 2003 fires, hospitals were encouraged to have their own evacuation plans and multi-site hospitals established protocol for patient relocation.

In addition to hospital patients in need of transportation assistance, the community of Rancho Bernardo is

Firewise Communities

The Firewise Communities program is a national and multi-agency effort that has been working since 1986 to educate and involve homeowners, community leaders, planners, developers, and others in fire-safe home construction, design, landscaping, and maintenance.

Firewise provides forums, workshops, and a newsletter that spread information about how community and land use planning, effective emergency response, and individual responsibility can reduce the loss of lives, property, and resources to wildland fire.

The Firewise approach emphasizes fire safety through building and maintenance practices that are compatible with natural surroundings. For more information, visit **www.firewise.org.**

home to a large number of independent living communities for elderly residents 55 and over. At the time of the 2007 fires, Scott Tarde was head of the skilled nursing facility at the Remmington Club, a 405-bed retirement community providing all levels of senior care.

Tarde was called at 4:00 a.m. and informed that he was to coordinate the evacuation of the 52 residents under his supervision. He attempted to activate the standing memorandum of understanding (MOU) between the Remington Club and an ambulance service, but to no avail. The county had commandeered all emergency vehicles. Tarde turned to his personal and professional contacts at other facilities to determine where to evacuate the residents. He identified available beds in multiple locations as he continued to search for some means of transporting his patients.

At this point, Tarde was contacted by the Medical Operations Center (MOC). The MOC response operations included anticipating and providing for the evacuation of hospitals and skilled nursing facilities; aiding communication between medical response personnel, other emergency responders, and the public; providing subject matter expertise; and assisting with medical aspects of shelter operations. The MOC offered to transport Remington Club residents who required assistance to the locations Tarde had identified.

After the fires, Scott Tarde expressed his frustration with the lack of preparedness and response capacity for evacuating the limited mobility and special needs populations of senior care and skilled nursing facilities. Although hospitals were integrated into evacuation plans, these types of facilities had not been fully incorporated into the protocols or training.

Now the executive director of the Remmington Club, Tarde as worked since the fall of 2007 to build a task force joining the 91 skilled nursing facilities in the county in a common goal: "We need a better way to communicate what resources are available."

The task force developed a system whereby facilities are grouped into one of seven areas, each with 10 to 15 facilities among which available beds and resources can be easily shared on short notice based on geography and common services. The task force and the protocol it developed are now fully integrated into the county plans and participate in the MOC. Tarde has been "thrilled with the response from the county" but recognizes that more still needs to be done to account for other vulnerable groups such as the developmentally disabled or board and care patients. In his experience, to offer the best care for these populations during emergencies, the "impetus (for hazard preparedness and planning) has to come from providers" who have already established working relationships and can best speak to needs and vulnerabilities.

LESSONS LEARNED SUMMARY: EVACUATING VULNERABLE POPULATIONS

Communities in Southern California have learned that evacuations run more smoothly if:

- Isolated communities involve local law enforcement in traffic management during an evacuation;
- Evacuation plans consider the need to educate tourists as well as locals;
- Hospitals have their own evacuation plans for patient relocation that are coordinated with community evacuation plans;
- MOUs are kept active and current and back-up plans are in place in case these fail;
- Plans for resource coordination among retirement homes assure availability of transport and shelter in an evacuation; and
- Service providers are involved directly in planning for evacuation.

CONCLUSION

Evacuations are one of the most obvious ways in which the transportation system participates in the disaster cycle. These mass movements of people require transportation infrastructure to support unusually high volumes of traffic, but also to function in ways that are totally unplanned for under normal conditions. The transportation system becomes a coordinated part of the response itself (e.g., by leaving one lane open to provide access for responders or providing transit options for those without independent means).

For this to happen seamlessly in the midst of an evacuation, coordinated planning must occur ahead of time. This case study has highlighted three issues that must be part of that preplanning to assure successful evacuation: coordinated response on all fronts (data gathering to command structure), integrated land use and transportation plans, and providing for the transportation needs of vulnerable populations.

Coordinated preplanning efforts not only improve decision making but can reduce the impact of a hazard and save lives.

After the Flames

Re-entry and the return of residents, as a first step toward recovery, can strain resources if not planned for and executed with care. To allow re-entry, more than just the fire lines must be considered. Depending on the jurisdiction and the hazard, as many as 30 different agencies and organizations could be a part of the re-entry decision. Waste management, sewer, hazmat, utilities, and health services, to name a few, all have a say. Dietrich noted that, in 2007, re-entry was more orderly than in 2003 because he and other incident commanders anticipated the requirements of the many organizations involved.

A Guide to Planning Resources on Transportation and Hazards

Case Study 3: Hazard Mitigation and an Alternative Approach to Transportation and Land Use in Fort Collins, Colorado

This case study highlights efforts to reduce flood risk in Fort Collins, Colorado. Land use planners, floodplain and stormwater managers, and multimodal transportation planners and engineers have all worked together to create a system of pedestrian and bicycle trails in the most flood-prone corridors in the city. This approach has helped to target capital investments in projects to meet multiple city goals. It also resulted in cost-effective risk reduction, improving amenities that the public enjoys every day.

BACKGROUND: GROWTH AND RISK REDUCTION IN FORT COLLINS

Fort Collins grew rapidly after World War II. It showed a steady pace of approximately 35-percent growth from 1980-1990, and another 35-percent gain from 1990-2000 (average growth of about 3 percent per year). This has increased the size of Fort Collins' urban core, spurred infill development, and at the same time forced the city to make decisions about where and how to accommodate new development around the urban edges. The Colorado landscape provides an expanse of space that has been traditionally agrarian and provides few topographic bounds to growth, but city planners found that the risk of seasonal flash flooding did have to be accommodated as the city grew.

Flash floods are short and intense hazard incidents that occur when heavy rain falls on saturated or poorly absorbent earth, resulting in sudden and dramatic rises in river and stream levels. Rainfall and snowmelt can cause flash floods, sometimes miles away from the initial melt or storm. Floodplain management in areas vulnerable to flash floods must prepare for these quick onset events with warning systems and other approaches because even high-capacity drainage infrastructure can easily be overwhelmed in a flood surge.

Colorado's Front Range, where Fort Collins is located, has a history of catastrophic flood events. On July 31, 1976, a thunderstorm dropped 12 inches of rain in less than four hours in the upper reaches of Big Thompson Canyon. In what was the largest flood on record at that time, 145 people lost their lives, over 900 structures were damaged, and Highway 34 was almost completely washed out. Almost exactly a year later, Fort Collins was inundated by the second largest one-day storm on record.

In 1980, the city established a stormwater utility—one of the first in the nation—to address some of its flood-related issues. Rates provide funding for capital improvement projects and help to maintain stormwater management as a city priority. Now with an annual budget of about $6 million, the utility oversees: system construction, repair, and maintenance; development review; floodplain administration; water quality issues; drainage master plans; and assists with emergency response through the Flood Warning System. The refinement of stormwater management strategies was spurred on by a 1997 flash flood; rainfall of 14.5 inches in 31 hours created over $200 million in property damages.

At the same time the city was investing in stormwater management infrastructure, it was also investing in other infrastructure needed to support growth. Fort Collins has made significant investments in its park system. Operational for over 100 years, the parks department offers 6 community parks and 38 neighborhood parks contributing to over 600 acres of parks and 5,000 acres of natural areas. Additionally, supporting a multimodal transportation system, the city provides 200 miles of on- and off-street trails for bikes and pedestrians.

Three incidents in the 1990s necessitated that Fort Collins reevaluate and strengthen its flood mitigation and preparedness strategy. The city began to connect the capital investments they were making in parks, transportation, and stormwater management to achieve mitigation goals. Mike Gavin, emergency manager for the City of Fort Collins, describes Fort Collins' approach to floodplain management as "aggressive" and "multisystem."

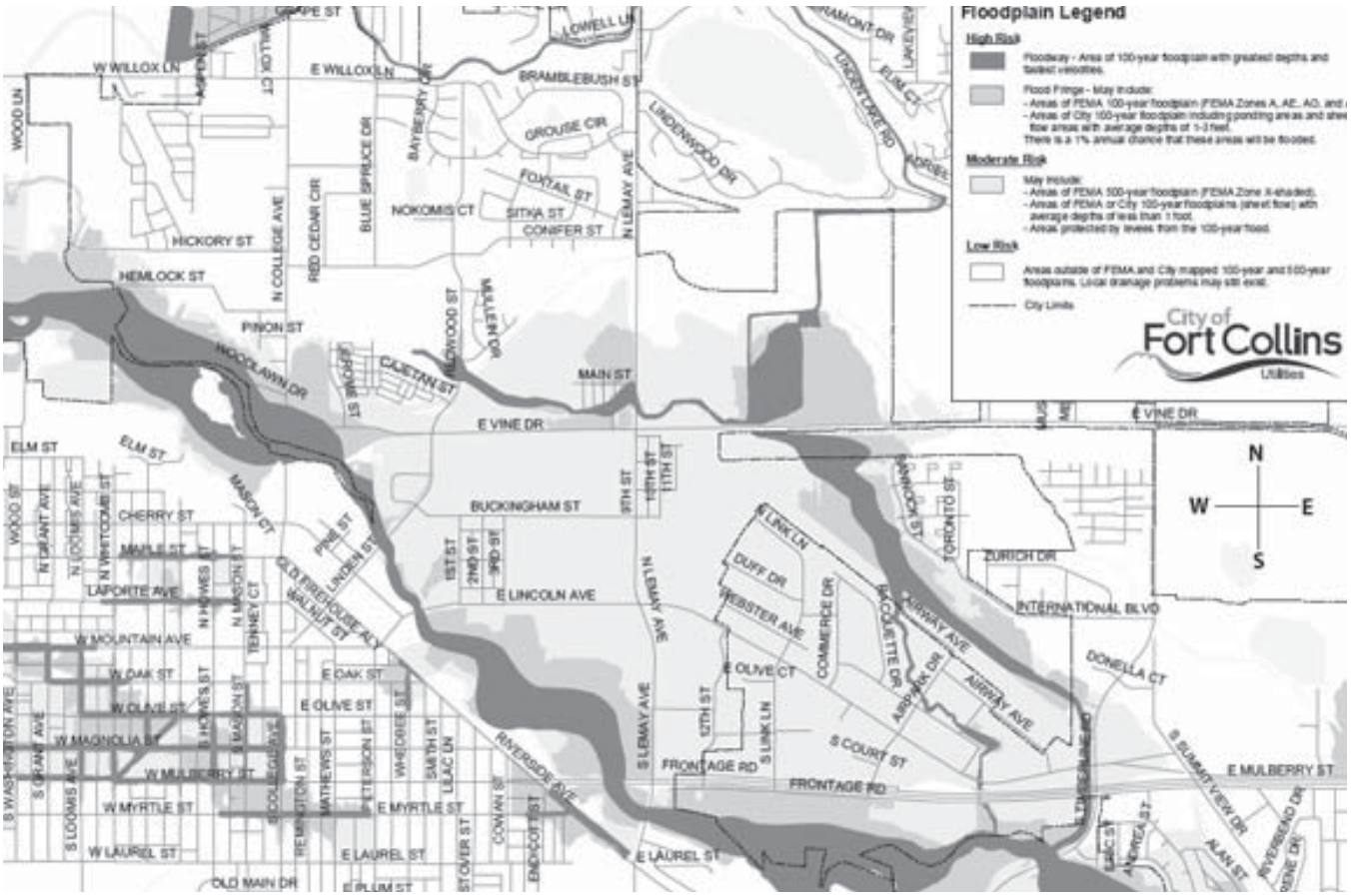
CONNECTING INVESTMENT CHOICES

Fort Collins has made strategic investments in the development of its transportation and flood infrastructure to serve the dual needs of the community: viable alternative transportation (bike and pedestrian) corridors (which also serve as open space) and flood mitigation. Both systems have been strengthened by their connected planning and implementation, allowing for the joint use of resources. Marsha Hilmes-Robinson, Fort Collins' floodplain administrator, credits the coordination of these capital projects for significant improvements in the city's ability to mitigate flood impacts. Mitigation strategies including strategic property acquisition, home and business relocation, advance notification strategies, and multimodal transportation projects are the cornerstones of Fort Collins' multifaceted mitigation strategy.

ACQUISITION AND RELOCATION

Though the destruction caused by the July 1997 flash flood was immense, forward thinking city developmental regulations and investment policies reduced the magnitude of the destruction. Key to saving lives and property from the 1997 flood was a series of capital investments focusing on reducing risk through property acquisition. Wrapped up by the mid 1990s, the effort coordinated land use regulations, flood management, and capital investments to purchase structures that lay in flood basins that

The Informer



Floodplain map for the northern half of Fort Collins.

Bicycle trail map for the northern half of Fort Collins.

were vulnerable to seasonal and flash floods. Fort Collins spent over $5 million on flood mitigation efforts including channelization, storm drainage improvement, reinforcement of rail embankments, bridge improvements, and the acquisition and relocation of structures in the floodplain to make room for pedestrian and bicycle trails. Stormwater utility funds were used to acquire 30 mobile homes, 9 residential structures, a retirement home, and a business located in a floodplain.

The retirement home proved to be the most controversial purchase and was the last structure to be relocated. After the 1997 flood, stormwater utility staff received a call from the retirement home community thanking them for the relocation program that was once a point of contention. The purchases are credited with saving an estimated 100 lives from the 1997 flood. Hilmes-Robinson observed the multipurpose function of the infrastructure improvements that reduced the number of at-risk structures and incorporated stream-side trails this way; the path, and crossings of the trails, when specifically designed for flood control "can be used to help back up other drainage systems, serve as detention, and slow down the water."

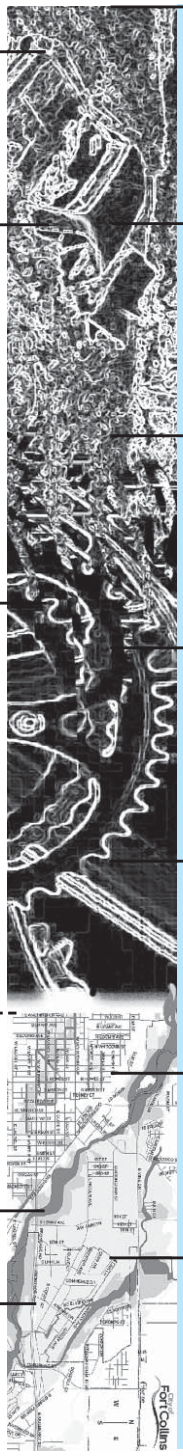
FLOOD NOTIFICATION SYSTEMS

In 1998, FEMA began a program called "Project Impact" that focused on enhancing capacity and community support for hazard prevention measures. The funding Fort Collins received for community outreach, hazard identification, flood mapping, and warning systems was a welcome boost for a community still recovering from the July 1997 flood.

Mike Gavin credits Project Impact and subsequent Hazard Mitigation Grant Programs (HMGP) with getting the ball rolling in significant ways: "Project Impact allowed us to start developing cutting edge systems for mitigation and notification." An HMGP grant helped to develop and implement the network of streamflow and rain gauges that are placed at vulnerable or upstream locations and constantly relay information into a database to help create water capacity projections. Incoming data are analyzed, and when built-in thresholds are met, alarms are engaged to notify stormwater and emergency operations staff, who then implement certain protocols.

The mapping system integrates the real-time information, as well as technical hydrological and hydraulic runoff modeling, and geographic realities of the area. An intergovernmental agreement among Larimer County, the 10 fire protection dis-

Fort Collins Timeline



July 31,1976: Big Thompson Flood devastates the region.

July 24,1977: Second largest one-day storm hits the area.

1980: Fort Collins Stormwater Utility District established.

1989-2004: Fort Collins spends over $5 million on channelization, storm drainage improvement, reinforcement of rail embankments, bridge improvements, and the acquisition and relocation of structures in the floodplain.

1995: The Fort Collins Bicycle Program Plan is created

July 28, 1997: 14.5 inches of rain triggers the Spring Creek Flood.

June 3, 1998: Fort Collins named a Project Impact community by FEMA.

1998-2004: Project Impact and subsequent investments develop city capacity for real-time flood inundation mapping and notification by establishing 35 stream gauges, 38 rain gauges, and five weather stations.

2004: Bicycle program is incorporated into city plan, linking flood buffer zones with bike paths.

2006: *Money Magazine* ranks Fort Collins #1 Great American Town.

September 24, 2008: Fort Collins earns gold level award from the League of American Bicyclists.

> The community will have a comprehensive, safe, and convenient bikeway system. The bikeway system will be designated to provide continuity and eliminate gaps in the system, while linking to regional systems. Bikeways will provide access to all major activity centers and destinations, by building on combinations or existing and planned commuter and recreational facilities.
>
> FORT COLLINS CITY PLAN TRANSPORTATION GOALS, 2004

tricts, and the cities and towns of the region established the Larimer Emergency Telephone Authority (LETA). This service provides e-mail, text, cell, and landline notification to residents of the region. Fort Collins' flood warning system is fully integrated, reaching from the streamflow, through the Office of Emergency Services, and directly to the residents who can receive rapid notification of the threat to their community and take action to protect themselves.

PLANNING GOALS FOR BIKE AND WATER CORRIDORS

Planning for dual use of public land is a third way in which Fort Collins provides for flood mitigation; bike corridors serve as overflow drainage, and stream-side buffers provide a prime location for bike paths. Fort Collins' transportation plan is grounded in building, sustaining, and improving multimodal service options and their connectivity. The city prioritized the provision of infrastructure to support bicycling as a "practical transportation choice for residents and visitors" (City of Ft. Collins 2004).

Throughout the city plan, trail connectivity is included as a principle not only for public land but to support and connect neighborhood employment and industrial development. Fundamental principles and policies articulated in the Fort Collins City Plan link the quality of transportation and riparian corridors. Though operated by different city agencies, maintaining the health of water corridors, protecting the citizenry from flood risk, and providing multiple viable modes of transportation is accomplished through comprehensive goals and interagency implementation of those goals.

The health and drainage capacity of regional water corridors is central to the environmental sustainability and flood resiliency of Fort Collins and the surrounding region. Marsha Hilmes-Robinson describes how "bike trails along streams are great compatible projects" to meet the goals of city parks and recreation, natural areas plans, and floodplain management. By purchasing land directly adjacent to waterways and preserving riparian habitat, the city creates a buffer that not only protects wildlife habitat, channel stability, and water conveyance, but also provides flood protection. Incorporating trail facilities into these off-street greenways achieves flood mitigation and hazard awareness through preventing development, applying stricter development regulations near these environmentally sensitive sites, and incorporating recreational and educational opportunities within the corridors.

FORT COLLINS INTO THE FUTURE

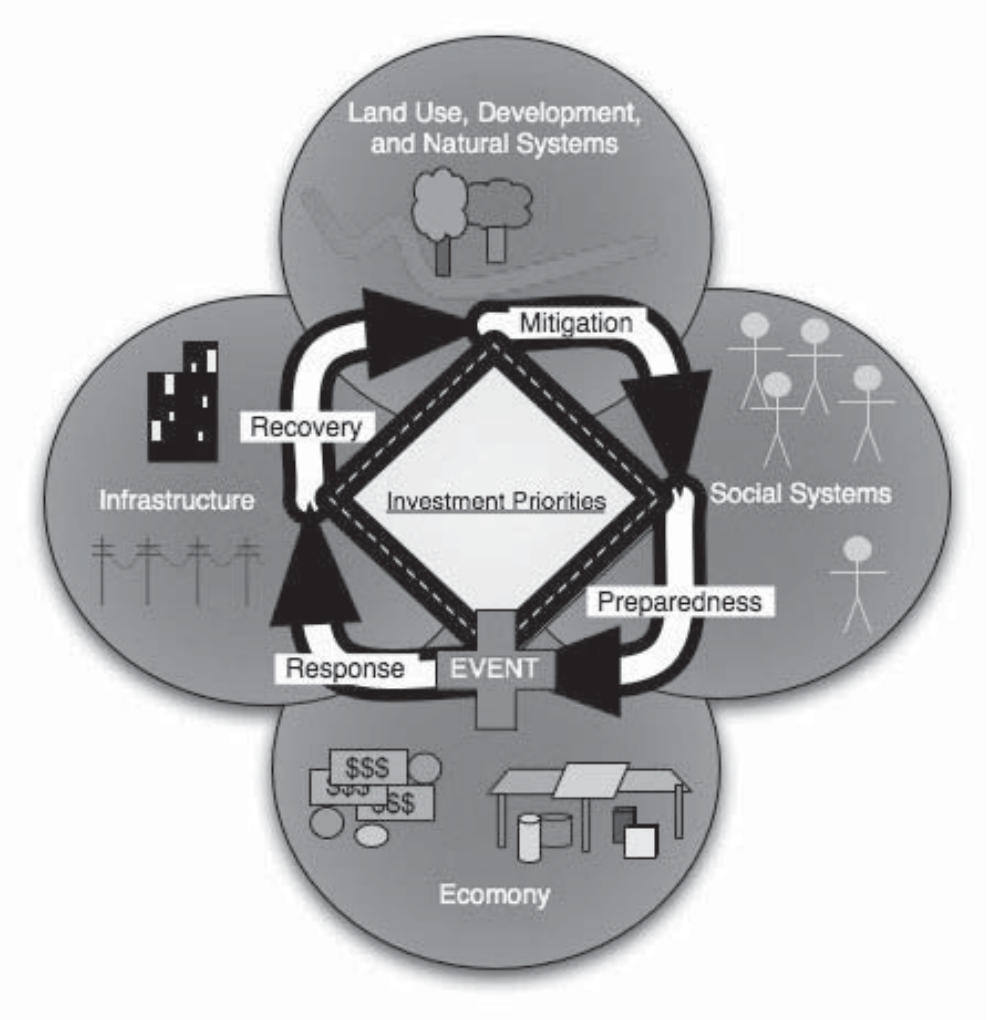
Mike Gavin is optimistic about the future of hazard mitigation in Fort Collins, anticipating that the trend of multipurpose and community-friendly solutions will continue. Gavin described a scenario where, in coordination, city agencies might purchase new parkland to improve connectivity of trails and use seasonally as a water retention area and snow hill. This collaborative problem solving meets multiple needs while using resources efficiently. Perhaps most importantly, it allows hazard mitigation measures to co-exist with other city priorities and encourage continued public support of such effort.

Marsha Hilmes-Robinson stressed the importance of the citywide master planning efforts. The full risk assessment recognized a larger area as floodplain based on updated rainfall information, classifying more structures as vulnerable to floods. She described how this reclassification provided an updated risk assessment implementing the comprehensive stormwater program desired by the public. After 1997, stormwater fees were changed to be consistent throughout the city instead of varying based on the floodplain basin. Rates are determined by the presence of impervious surfaces on a property. In this way the city encourages residents and new development to consider the impact of individual structures on drainage and flood management.

Fort Collins' experience demonstrates how — through an interagency approach to mitigation — collaborative projects not only achieve multiple agency goals, but can increase the long-term acceptability of hazard mitigation as a city and community goal. Additionally, joint investment in strategic open space provides hazard mitigation along with urban amenities. A string of recent awards has recognized Fort Collins for its commitment to providing public space for the community's enjoyment and a viable network for bicycle and pedestrian traffic. These investment priorities ensure that Fort Collins serves as a national model for supporting both hazard mitigation and alternative transportation.

A Guide to Planning Resources on Transportation and Hazards

Chapter 8: Conclusion



The figure at right illustrates the systems connections that this document has described: the economy cannot function without infrastructure to support it, but that infrastructure cannot be created without the economy to provide materials and labor; the demographic makeup of society influences the organization of our built environment and the market conditions in which economic transactions occur.

The transportation network is critical to the success of this framework. It is a system unto itself, simultaneously influenced by and affecting all of the other systems. But it also literally connects all of the other systems to each other. A safe, efficient, and resilient transportation system is a fundamental component of our society every day and during a crisis. Transportation planning efforts that fail to realize the importance of the interaction among systems threaten to increase vulnerability rather than decrease it.

Historically, our transportation needs and choices have greatly affected development patterns and our economy. Major cities developed around ports and rivers because they had the greatest access to economic resources (including jobs and income) and goods. These locations were often hazard-prone floodplains and coastal areas; we have inherited a development pattern that is more vulnerable than it might otherwise have been as a direct result of the interaction between the transportation system and the economy.

As the transportation system has changed, so too has our development pattern and the type of risk that we incur as a result. When railroads were built and became a viable mode of transportation, population shifted to towns and cities along rail lines that were newly accessible and opened up new opportunities for economies based on resource extraction. Our more recent collective investment in roads and airline infrastructure means the rapid and efficient flow of goods and increased mobility of the population, but it also means that people are choosing to live in cities for new reasons: climate, proximity to recreation opportunities, and housing prices. Some of the fastest growing cities in our country are now located in geographies that carry a new set of risks: lack of long-term clean water supply, wildfires, and drought.

A key question for transportation engineers and planners to consider: if our choices about transportation have contributed to riskier development in the past, can our choices in the future increase our overall resilience? The case study in Fort Collins and a new focus on alternative modes of transportation and transit would imply that the answer is "yes." Case studies about coordinated port security efforts and Southern California wildfire evacuations provide other examples.

Transportation planners and policy makers know, to a large extent, the weakness of the transportation system. Now, the field must endeavor to understand a more complex set of interactions over the course of the disaster cycle. Given the transportation system role as key to the proper functioning of our economic, social, and built environment systems:

- How can the transportation system help people prepare?

- How will the system be called upon to respond to and facilitate response?
- What are the priorities for long-term investments in a recovery scenario, and how can transportation investments now help to assure recovery of the nation's economic and social systems when disasters occur?
- What economic, social, and physical vulnerabilities exist that transportation improvements could mitigate?

Vulnerability is incurred by physical systems and social systems and investment to strengthen either will support the resiliency of both. Investments in transportation infrastructure can strengthen resiliency in the face of disaster by addressing physical and social vulnerability together. The potential for alternative modes of transportation to reduce our collective vulnerability in the future is compelling and should be explored. A multimodal system will serve to increase connectivity, redundancy, and access.

Transportation planners and engineers can cross professional fields to engage in preparedness and mitigation discussions with people outside the transportation realm to gather information about their decisions as well as to educate others about transportation issues. Health care providers, land use planners, and environmental scientists all have knowledge and resources that can be brought to bear to reduce vulnerability. Effective plans for network expansion and security depend on interdisciplinary collaboration and coordination.

Disasters are inevitable, and the centrality of the transportation system in our daily lives and in a crisis means that it is incumbent on all of us to create a secure transportation system that is integrated with other critical systems. This resilient system will reduce the direct and indirect consequences of a disaster before, during, and after the event and ultimately enhance quality of life for all.

Key Conclusions

• Historically, our transportation needs and choices have been driven by economic needs and have greatly affected development patterns. We have therefore inherited a development pattern that is more vulnerable than it might otherwise have been as a direct result of the interaction between the transportation system and the economy.

• Transportation planning efforts that fail to realize the importance of the interaction among systems may increase vulnerability rather than decrease it.

• Investments in transportation infrastructure can strengthen resiliency in the face of disaster by addressing physical and social vulnerability together and by addressing the transportation system in the context of the systems with which it interacts.

• Our choices now can increase our overall resilience in the future.

A Guide to Planning Resources on Transportation and Hazards

Appendix: Works Cited and Reviewed

WORKS CITED

Abramovitz, Janet. 2001. *Unnatural Disasters*. Worldwatch Paper 158. Washington, D.C.: Worldwatch Institute.

Alesch, Daniel J. 2001. *Complex Urban Systems and Extreme Events: Toward a Theory of Disaster Recovery*. Public Entity Risk Institute. **www.riskinstitute.org/peri/index.php?option=com_bookmarks&task=detail&id=101**.

American Society of Civil Engineers (ASCE). 2005a. *National Fact Sheet*. **www.asce.org/reportcard/2005/page.cfm?id=145** (accessed 27 July 2008).

American Society of Civil Engineers (ASCE). 2005b. *Report Card for America's Infrastructure*. **www.asce.org/reportcard/2005/index.cfm.**

Burby, Raymond J., Robert E. Deyle, David R. Godschalk, and Robert B. Olshansky. 2000. Creating Hazard Resilient Communities through Land-Use Planning. *Natural Hazards Review* 1 (2): 99-106.

Burby, Raymond J., Arthur C. Nelson, Dennis Parker, and John Handmer. 2001. Urban Containment Policy and Exposure to Natural Hazards: Is There a Connection? *Journal of Environmental Planning and Management* 44 (4): 475-490.

Chang, S. E. 2003. Evaluating Disaster Mitigations: Methodology for Urban Infrastructure Systems. *Natural Hazards Review* 4 (4): 186-196.

City of Fort Collins. 2004. Community Planning and Environmental Services, Advance Planning Department. *Fort Collins City Plan*.

Clarkson, Capt. James S., USCG (Ret.) and Commander Richard M. Gaudiosi, USCG (Ret.). 2007. TSA's PortSTEP: Exercising Risk Mitigation in the Port Transportation Network. *Proceedings of the Marine Safety and Security Council* G4 (1): 49-52.

Cova, Thomas J. 2005. Public Safety in the Urban–Wildland Interface: Should Fire-Prone Communities Have a Maximum Occupancy? *Natural Hazards Review* 6 (3): 99-108.

Cutter, Susan L., Jerry T. Mitchell, and Michael S. Scott. 2000. Revealing the Vulnerability of People and Places: A Case Study of Georgetown County, South Carolina. *Annals of the Association of American Geographers* 90 (4): 713-737.

Eisenman, D. P., Kristina M. Cordasco, Steve Asch, Joya F. Golden, and Deborah Gilk. 2007. Disaster Planning and Risk Communication with Vulnerable Communities: Lessons from Hurricane Katrina. *American Journal of Public Health* 97 (S1): S109-S115.

Eldar, K., Sudha Xirasagar, Nancy Miller, Shelly Ann Bowen, Saundra Glover, and Crystal Piper. 2007. African Americans' Decisions Not to Evacuate New Orleans Before Hurricane Katrina: A Qualitative Study. *American Journal of Public Health* 97 (S1): S124-S129.

Federal Highway Administration. 2008. *Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring*. **www.fhwa.dot.gov/environment/ultraurb/fig1txt.htm.**

Freeman, Paul K., Leslie A. Martin, Reinhard Mechler, Georg Pflug, and Koko Warner. 2004. A Methodology for Incorporating Natural Catastrophes Into Macroeconomic Projections. *Disaster Prevention and Management* 13 (4): 337-342.

Ganderton, P. T. 2005. Benefit-Cost Analysis of Disaster Mitigation: A Review. Mitigation and Adaptation Strategies for Global Change. *Special Issue: International Perspectives of Mitigation of Natural Hazards and Disasters* 10 (3): 445-465.

Godschalk, D. R. 2003. Urban Hazard Mitigation: Creating Resilient Cities. *Natural Hazards Review* 4 (3): 136-143.

James, X., Anita Hawkins, and Randy Rowel. 2007. An Assessment of the Cultural Appropriateness of Emergency Preparedness Communication for Low Income Minorities. *Journal of Homeland Security and Emergency Management* 4 (3): Article 13.

Kentucky Cabinet for Health and Family Services, Division of Communications. 2008. *Kentucky Outreach and Information Network Fact Sheet*. **chfs.ky.gov/dph/epi/preparedness/KOIN.htm**.

Kloss, C. and C. Calarusse. 2006. *Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows*. New York: Natural Resources Defense Council.

LeDuc, Andre. 2006. Establishing Mitigation as the Cornerstone for Community Resilience. *The 2006 Risk Management Yearbook.*

Lindsay, J. R. 2003. The Determinants of Disaster Vulnerability: Achieving Sustainable Mitigation through Population Health. *Natural Hazards* 28 (2-3): 291-304.

Massey, Douglas and Nancy Denton. 1998. *American Apartheid: Segregation and the Making of the Underclass.* Cambridge: Harvard University Press.

Mather, Mark. 2008. *Population Losses Mount in U.S. Rural Areas*. Population Reference Bureau. **www.prb.org/Topics/ImmigrationMigration.aspx**.

McIvor, David and Douglas Paton. 2007. Preparing for Natural Hazards: Normative and Attitudinal Influences. *Disaster Prevention and Management* 16 (1): 79-88.

Mileti, D. S. 1999. *Disasters by Design: A Reassessment of Natural Hazards in the United States*. Washington, D.C. Joseph Henry Press.

Multihazard Mitigation Council, National Institute of Building Sciences. 2005. *Natural Hazard Mitigation Saves: An Independent Study to Asses the Future Savings from Mitigation Activities*. **www.nibs.org/MMC/mmcactiv5.html**.

National Center for Pavement Preservation. 2008. *National Center for Pavement Preservation (NCPP).* **www.pavementpreservation.org**.

Olshansky, R. B. 2005. *How Do Communities Recover from Disaster? A Review of Current Knowledge and an Agenda for Future Research*. 46th Annual Conference of the Association of Collegiate Schools of Planning.

Pacific NorthWest Economic Region. 2007. *Pacific NorthWest Economic Region.* **www.pnwer.org.**

Paton, D. 1999. Disaster Business Continuity: Promoting Staff Capability. *Disaster Prevention and Management* 8 (2): 127-133.

Pelling, M. 2002. The Macro-Economic Impact of Disasters. *Progress in Development Studies* 2 (4): 283-305.

Petak, W. 1998. Mitigation and Insurance. In *Paying the Price: The Status and Role of Insurance against Natural Disaster in the United States*, edited by Howard Kunreuther and Richard J. Roth Sr., 155-170. Washington, D.C.: Joseph Henry Press.

Platt, Rutherford H. 2008. After Sprawl: The Humane Metropolis. *Land Lines* 20 (3).

Schnirring, Lisa. 2008. *Breaking Language Barriers with Preparedness Messages*. St. Paul: University of Minnesota Center for Infectious Disease Research & Policy. **www.cidrap.umn.edu/cidrap/content/influenza/panflu/news/jun3008ppecho.html**.

Schwab, Jim, K.C. Topping, C.C. Eadie, R.E. Deyle, and R.A. Smith. 1998. *Planning for Post-Disaster Recovery and Reconstruction*. Chicago: American Planning Association and the Federal Emergency Management Agency.

Swiss Re. 2008. *Sigma: Natural Catastrophes and Man-Made Disasters in 2007*. No. 1/2008. **www.swissre.com/sigma**.

U.S. Congress. *Disaster Mitigation Act of 2000*. 106th Congress, 114 STAT. 1553, 2000.

U.S. Congress. *Maritime Transportation Security Act of 2002*. 107th Congress, 116 STAT. 2064, 2002.

U.S. Department of Homeland Security. 2005. *National Security Presidential Directive 41/Homeland Security Presidential Directive 13 (NSPD 41/HSPD 13).* **www.dhs.gov/xprevprot/programs/editorial_0608.shtm.**

U.S. Department of Homeland Security. 2007. *Critical Infrastructure and Key Resources.* **www.dhs.gov/xprevprot/programs/gc_1189168948944.shtm**.

U.S. Department of Homeland Security. 2008. *The National Incident Management System (NIMS): FEMA 501/Pre-Decisional Draf*t. Washington, D.C.: Federal Emergency Management Agency.

U.S. Department of Homeland Security. 2006. *The National Infrastructure Protection Plan (NIPP).* Washington, D.C.: Department of Homeland Security.

U.S. Department of Transportation, Federal Highway Administration (FHWA), Office of Operations. 2006. *Best Practices in Emergency Transportation Operations Preparedness and Response: Results of the FHWA Workshop Series.* Washington, D.C.: Federal Highway Administration.

U.S. Environmental Protection Agency, Development, Community, and Environment Division. 2001. *Our Built and Natural Environments: A Technical Review of the Interactions between Land Use, Transportation, and Environmental Quality*. Washington, D.C.: U.S. Environmental Protection Agency.

Wolshon, Brian. 2008. New Developments and Shifting Focus in Mass Evacuation. *Natural Hazards Observer*, 32 (6): 1-3.

WORKS REVIEWED

Allenby, Brad and Jonathan Fink. 2005. Toward Inherently Secure and Resilient Societies. *Science* 309 (5737): 1034-1036.

Barbarosoglu, G. and Y. Arda. 2004. A Two-Stage Stochastic Programming Framework for Transportation Planning in Disaster Response. *The Journal of the Operational Research Society* 55 (1): 43-53.

Benson, Charlotte and Edward Clay. 2003. *Economic and Financial Impacts of Natural Disasters: An Assessment of Their Effects and Options for Mitigation, Synthesis Report.* London: Overseas Development Institute.

Board on Natural Disasters of the Natural Research Council. 1999. Mitigation Emerges as Major Strategy for Reducing Losses Caused by Natural Disasters. *Science* 284: 1943-1947.

Bruneau, M., S. E. Chang, R. T. Eguchi, G. C. Lee, T.D. O'Rourke, A. M. Reinhorn, M. Shinozuka, K. Tierney, W. A. Wallace, and D. von Winterfeldt. 2003. A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities. *Earthquake Spectra* 19 (4): 733-752.

Cardona, O. D. 2004. The Need for Rethinking the Concepts of Vulnerability and Risk from a Holistic Perspective: A Necessary Review and Criticism for Effective Risk Management. In *Mapping Vulnerability: Disasters, Development, and People*: 37-51. Ebbw Vale, Wales: Earthscan.

Chang, Stephanie E. and Masanobu Shinozuka. 2004. Measuring and Improving the Disaster Resilience of Communities. *Earthquake Spectra* 20 (3): 739-755.

Cova, Thomas J. and Steven Conger. 2004. Transportation Hazards. In *Handbook of Transportation Engineering* edited by Myer Kutz, 17.1-17.24. New York: McGraw Hill.

A Guide to Planning Resources on Transportation and Hazards

Cova, Thomas J. and Justin Johnson. 2002. Microsimulation of Neighborhood Evacuations in the Urban-wildland Interface. *Environment and Planning* 34: 2211-2229.

Kunreuther, H. 1998. Insurability Conditions and the Supply of Coverage. In *Paying the Price: The Status and Role of Insurance Against Natural Disaster in the United States*: 17-50. Washington, D.C.: Joseph Henry Press.

Little, R. G. 2003. Toward More Robust Infrastructure: Observations on Improving the Resilience and Reliability of Critical Systems. 36th Annual Hawaii International Conference on System Sciences.

McEntire, D. A. 2001. Triggering Agents, Vulnerabilities and Disaster Reduction: Towards a Holistic Paradigm. *Disaster Prevention and Management* 10 (3): 189-196.

Midkiff, Scott F. and Charles W. Bostian. 2002. *Rapidly-Deployable Broadband Wireless Networks for Disaster and Emergency Response*. Presented at The First IEEE Workshop on Disaster Recovery Networks (DIREN '02), June 24, 2002, New York City, NY.

Modarres, M. and B. Zarei. 2002. Application of Network Theory and AHP in Urban Transportation to Minimize Earthquake Damages. *The Journal of the Operational Research Society* 53 (12): 1308-1316.

Pearce, L. 2003. Disaster Management and Community Planning, and Public Participation: How to Achieve Sustainable Hazard Mitigation. *Natural Hazards* 28 (2-3): 211-228.

Perry, Ronald W. and Michael K. Lindell. 2003. Preparedness for Emergency Response: Guidelines for the Emergency Planning Process. *Disasters* 27 (4): 336-350.

Rose, A. 2004. Defining and Measuring Economic Resilience to Disasters. *Disaster Prevention and Management* 13 (4): 307-314.

Schwab, Anna and David Brower. 1999. *Sustainable Development and Natural Hazards Mitigation*. North Carolina: The Mitigation Planning Initiative Group, North Carolina Department of Crime Control and Public Safety Division of Emergency Management.

Siembieda, W. 2005. *Reducing Disaster Risk: Investing in Mitigation and Preparedness.* Prepared for the International Symposium on Urban Disaster Risk Reduction and Regeneration, held at California Polytechnic State University- San Luis Obispo, November 3-5, 2005.

Smith, T. A. 2004. *The Inherent Challenges of Securing Transportation Infrastructure*. International Summer Academy on Technology Studies – Urban Infrastructure in Transition. 353-364.

Spiker, Elliott C. and Paula L. Gori. 2003. *National Landslide Hazards Mitigation Strategy—A Framework for Loss Reduction*. Washington, D.C.: U.S. Department of the Interior and the U.S. Geological Survey.

Veen, A. 2004. Disasters and Economic Damage: Macro, Meso, and Micro Approaches. *Disaster Prevention and Management* 13 (4): 274-279.

White, Philip and Mark Pelling. 2004. *Disaster Risk Reduction: A Development Concern.* Norwich: Overseas Development Group.

INTERVIEWEES

Ambrosia, Vincent. Principal Investigator, Western States Unmanned Aerial System Fire Mission at NASA's Ames Research Center.

Cannon, Sue. United States Geological Survey Research Geologist.

Cova, Thomas. University of Utah Associate Professor and Director of the Center for Natural and Technological Hazards.

Dietrich, Mike. San Bernardino National Forest Fire Chief and a National Incident Commander.

Fischer, Mike. Former Director of Security for the Port of Baltimore and current Homeland Security Advisor to the Maryland Secretary of Transportation.

Gaudiosi, Richard M., Commander, USCG (Ret).

Gavin, Mike. City of Fort Collins Emergency Manager.

Hilmes-Robinson, Marsha. City of Fort Collins Floodplain Administrator.

Lochra, Chris. Fort Collins Stormwater Utility.

McCaffrey, Sarah. United States Department of Agriculture Forest Service Research Social Scientist.

Natural Hazards Center

The mission of the Natural Hazards Center is to advance and communicate knowledge on hazards mitigation and disaster preparedness, response, and recovery. Using an all-hazards and interdisciplinary framework, the Center fosters information sharing and integration of activities among researchers, practitioners, and policy makers from around the world; supports and conducts research; and provides educational opportunities for the next generation of hazards scholars and professionals. The Natural Hazards Center is funded through a National Science Foundation grant and supplemented by contributions from a consortium of federal agencies and nonprofit organizations dedicated to reducing vulnerability to disasters.

Staff

Jolie Breeden ..... Research Associate
Christine Bevc ..... Research Assistant
RoseMarie Perez Foster ..... Senior Research Associate
Brandi Gilbert ..... Research Assistant
Wanda Headley ..... Library Manager
Alexandra Jordan ..... Research Assistant
Ezekiel Peters ..... Program Manager
Liesel A. Ritchie ..... Research Coordinator
Diane Smith ..... Office Manager
Jeannette Sutton ..... Research Coordinator
Kathleen Tierney ..... Director
Dan Whipple ..... Editor

Research Affiliates

Dennis S. Mileti ..... Rancho Mirage, CA
Leysia Palen ..... University of Colorado at Boulder
Lori Peek ..... Colorado State University
Deborah Thomas ..... University of Colorado at Denver

Send items of potential interest to *Informer* readers to the Natural Hazards Center, University of Colorado at Boulder, 482 UCB, Boulder, CO 80309-0482; (303) 492-6818, (303) 492-2151 (fax); hazctr@colorado.edu.

The Natural Hazards Informer

The Natural Hazards *Informer* is published irregularly by the Natural Hazards Center at the University of Colorado at Boulder. The *Informer* provides a concise, peer-reviewed synthesis of state-of-the-art research on specific hazard issues. Its purpose is to provide natural hazards practitioners and emergency managment specialists knowledge they can use to better prepare for, respond to, recover from, and mitigate the effects of natural disasters.

We welcome ideas for other issues of the *Informer*. If you have an idea or are interested in writing an accessible, state-of-the-art review on a topic for a future issue, contact Jeanette Sutton, suttonj@colorado.edu.

Transportation Research Board
500 Fifth Street, NW
Washington, DC 20001

THE NATIONAL ACADEMIES™
Advisers to the Nation on Science, Engineering, and Medicine

The nation turns to the National Academies—National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council—for independent, objective advice on issues that affect people's lives worldwide.
www.national-academies.org

These digests are issued in order to increase awareness of research results emanating from projects in the Cooperative Research Programs (CRP). Persons wanting to pursue the project subject matter in greater depth should contact the CRP Staff, Transportation Research Board of the National Academies, 500 Fifth Street, NW, Washington, DC 20001.