A Pre-Event Recovery Planning Guide for Transportation

DETAILS

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP REPORT 753

A Pre-Event Recovery Planning Guide for Transportation

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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Patricia Bye, Synthosys, was the principal investigator and lead author. Linda Yu, Synthosys, was co-author and Shubha Shrivastava and Simon van Leeuwen of URS Infrastructure & Environment Division, Germantown, MD, were contributing authors of this report. Other research team members include Ernest "Ron" Frazier, Jr., Esq., of Countermeasures Assessment and Security Experts, LLC (CASE™), who conducted the legislative and legal review; Robert Mahoney and Elisa Nichols of Kensington Consulting; Robert Brodesky and Amit Mahadevia of URS Infrastructure & Environment Division; and Linda Yu of Synthosys who performed case study interviews and prepared draft case studies. Vicki Glenn and LisaBeth Weber edited the draft documents, and Stephanie Watson, former graduate student of University of Alabama, Birmingham, assisted in the literature search.

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FOREWORD

By Stephan A. Parker
Staff Officer
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NCHRP Report 753: A Pre-Event Recovery Planning Guide for Transportation (The Guide) provides an overview of what can be done to prepare for the recovery of transportation critical infrastructure. Principles and processes based on federal guidance, effective practices, and lessons from case studies are provided to guide transportation owners and operators in their efforts to plan for recovery prior to the occurrence of an event that impacts transportation systems. Tools and resources are included to assist in both pre-planning for recovery and implementing recovery after an event.

The Guide is intended to provide a single resource for understanding the principles and processes to be used for pre-event recovery planning for transportation infrastructure. In addition to the principles and processes, the Guide contains checklists, decision support tools, and resources to support pre-event recovery planning. The Guide will be of interest to transportation infrastructure owners/operators, transportations planners, and practitioners at the state and local levels.

Under NCHRP Project 20-59(33), Synthosys, LLC, was asked to develop a guide that provides pre-event recovery planning principles, processes, tools, and appended resource materials for use by planners and decision-makers in pre-event planning to support transportation infrastructure recovery. The report and a PowerPoint presentation describing the entire project are available on the TRB website at www.trb.org/securitypubs.

CONTENTS

Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the Web at www.trb.org) retains the color versions.

SUMMARY

A Pre-Event Recovery Planning Guide for Transportation

NCHRP Report 753: A Pre-Event Recovery Planning Guide for Transportation (Guide) provides an overview of what can be done to prepare for the recovery of transportation critical infrastructure prior to an event that impacts transportation systems. Guidance and effective practices from current experience and case studies are summarized to guide transportation owners and operators in their efforts to plan for recovery. The main audience for this document is transportation owners/operators and transportation planners and practitioners at the state and local levels.

This Guide is intended to provide a single resource for understanding the principles and processes to be used for pre-event recovery planning for transportation infrastructure. In addition to the principles and processes, the Guide contains checklists, decision-support tools, and resources to support pre-event recovery planning.

Chapter 1 provides a conceptual overview of recovery and the current state of recovery planning. The chapter highlights the need to pre-plan for recovery and demonstrates the benefits of doing so, with examples from recent catastrophic events that disrupted transportation systems.

Chapter 2 provides an overview of the federal authorities that guide recovery including national strategies, executive orders, and presidential directives.

Chapter 3 presents the principles of pre-event recovery planning, the overarching tenets identified through case studies and review of the literature of recovery.

Chapter 4 presents lessons and effective practices derived from case studies conducted under NCHRP Project 20-59(33) and a review of existing transportation infrastructure recovery case studies.

Chapter 5 provides guidance for the critical decisions and major tasks of pre-event recovery planning based on recovery "keys to success"—the decisions, actions, and processes that can help expedite the overall recovery process. Checklists, decision-support tools, and other resources are included to support the recommended approaches.

Chapter 6 provides a summary of recovery funding sources and includes a comparison of the primary federal recovery emergency funding programs for transportation infrastructure: FHWA Emergency Relief (ER) and Federal Emergency Management Agency (FEMA) Public Assistance (PA).

Emergency recovery often brings together people who may not work together during non-emergency situations. Chapter 7 addresses what can be done prior to an event to improve communications and coordination during recovery.

Chapter 8 provides an overview of recovery management policies and practices that can help expedite recovery, including streamlining administration and accelerating the approval process.

Additional information compiled by the NCHRP Project 20-59(33) research team is provided in appendices. Appendix A provides a listing of tools and resources compiled by the research team that can assist in pre-event planning for recovery and post-event recovery. The tools and resources are organized by the key tasks and decisions of pre-event recovery. Checklists, worksheets, and online toolboxes are listed first, followed by guidance and resource documents.

Appendix B provides the five in-depth case studies developed by the NCHRP Project 20-59(33) research team and an additional case study based on a few forward-looking jurisdictions that have instituted policies, programs, and tools that can assist in recovery. In Appendix C, the research team provides an overview of damage assessment and its impact on expediting recovery, and in Appendix D the team provides an overview of decontamination techniques. Appendix E provides detailed information on recovery funding sources. Appendix F provides a glossary of common recovery-related terms.

CHAPTER 1

Introduction

Recovery after a catastrophic event is a complex and challenging process. It involves addressing complicated questions about whether, and in what way, to repair or replace damaged infrastructure. It brings together people and organizations that may not usually work together in day-to-day operations or non-emergency situations. Recovery is dependent upon a range of factors that both precede and follow the actual catastrophic event. There is little time to resolve the tension between achieving fast results and making needed improvements.

The pressures of getting "up and running" and "back to normal" are intense in a post-disaster situation. Usually a gradual process (depending on the type and extent of damage done), recovery can continue for months or even years after the event, from the initial restoration of some level of operations through the longer term reconstruction of critical infrastructure.

Although recovery is a critical step in the emergency response cycle, it is one of the least understood aspects of emergency management. Many state departments of transportation (DOTs) and public transportation agencies have emergency response plans that address immediate operational situations, e.g., Continuity of Operations Plans (COOPs). Few, however, have emergency recovery plans prepared in advance. Most often, planning for recovery happens only after a disaster occurs. As noted by the Federal Emergency Management Agency (FEMA) in standard materials prepared for emergency management training, "Although planning is an action that is conducted in all four of the primary emergency management functions (preparedness, response, recovery, and mitigation), it is more commonly associated with preparedness and mitigation prior to the event" (FEMA Emergency Management Institute).

Preparing for recovery before an event can speed recovery after an event. For instance, in 2007, when a gasoline tanker accidentally crashed on the MacArthur Maze in Oakland, California, one of the busiest freeway interchange systems in the United States, two key highway connectors on heavily traveled Interstate 80 near the San Francisco Bay Bridge collapsed in a gasoline fire. The local media projected that the connectors would be down from 5 months to a year and that traffic in the East Bay would be gridlocked indefinitely. Instead, 26 days after the incident, the rebuilt connectors for the Maze were reopened to traffic.

Having emergency expedited contracting and procurement processes in place along with a list of pre-approved contractors allowed Caltrans to significantly reduce the time required to repair the damaged MacArthur Maze. Within

FEMA Definition of Recovery

"Full restoration of operability" that includes

- Development, coordination, and execution of service- and site-restoration plans.
- Reconstitution of government operations and services.
- Additional measures for social, political, environmental, and economic restoration.
- Evaluation of the incident to identify lessons learned.
- Post-incident reporting.
- Development of initiatives to mitigate the effects of future incidents.

Source: *Comprehensive Preparedness Guide (CPG) 101: Producing Emergency Plans—A Guide for All-Hazard Emergency Operations Planning for State, Territorial, Tribal, and Local Governments.* Interim Version 1.0 (FEMA 2008).

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days of the governor's invocation of emergency procedures on the day of the incident, several contractors were brought on the job. Usually, this process takes months. Bids for the rebuilding project were advertised on a Thursday and the contractor was selected by the following Monday.

In another example, in 2002, a barge veered several hundred feet off course and struck the Interstate 40 Bridge crossing the Arkansas River in Webbers Falls, Oklahoma. The collision caused the bridge, part of a major east-west transportation corridor, to plunge into the river. Sixty-five days after the accident, the bridge reopened to traffic.

The I-40 Bridge in Oklahoma is located in an area of both farmland and forest, where some land was owned by the Cherokee Nation and some was owned by the U.S. Army Corps of Engineers (USACE) but managed as a wildlife refuge by the U.S. Fish and Wildlife Service. Although the bridge was being replaced at its original location, reconstruction required creating a riverside staging area and actual construction in the river channel. The Oklahoma Department of Transportation's (ODOT's) strong pre-existing relationships with the state and federal agencies involved enabled the use of informal emergency procedures to expedite the recovery. For example, because obtaining a required Section 404 permit from USACE can be a lengthy process, ODOT was allowed to apply for the permit after the construction was complete.

Along with repair and reconstruction, recovery can create the opportunity to "build back better." When the I-35 Bridge in Minneapolis, Minnesota, suddenly collapsed into the Mississippi River (2007), the NTSB investigation found that a flaw in the initial design contributed to the collapse. The construction of the new I-35 Bridge allowed the Minnesota Department of Transportation (MnDOT) to incorporate improvements that addressed the "black ice" problem that had frequently occurred on the old bridge. The new I-35 Bridge has the world's largest anti-icing system and uses smart bridge technology to generate a record of how the bridge manages the stresses of traffic. Moreover, the new bridge opened to traffic on Thursday, September 18, 2008, more than 3 months ahead of schedule.

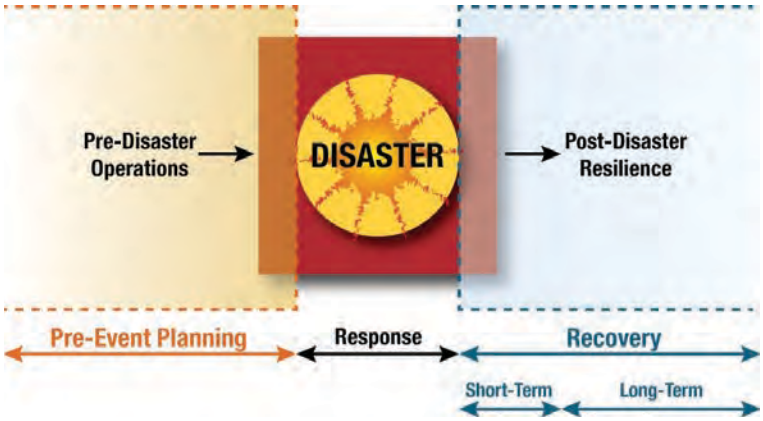
Recovery is typically considered to be a series of discrete efforts that take place after an event or disaster and is often considered in phases: an emergency/response recovery period, short-term recovery, and long-term recovery/reconstruction, as illustrated in Figure 1.

- During the emergency/response recovery period (typically 1 to 7 days after the event), damage assessments are made; debris clean-up/removal starts; emergency, often short-term, repair of transportation systems occurs; and interim transportation services are provided, if necessary.
- During the short-term recovery period, emergency demolitions occur and temporary structures and infrastructure may be put in place to replace damaged infrastructure.
- Long-term recovery (typically several years) consists of the permanent reconstruction and restoration of the transportation system infrastructure.

Depending on the severity of the event, disaster declarations and federal assistance may be involved. It has been noted that the restoration of transportation infrastructure involves a continuous process of assessment, prioritization, mitigation, and repair. As more specific information becomes available about the extent of damage and requirements for repairs, priorities may be adjusted and short- and long-term strategies may be revised.

The National Disaster Recovery Framework (NDRF) considers recovery as a **process that begins prior to an event and continues afterwards**, as illustrated in Figure 2.

As the examples of recovery in California, Oklahoma, and Minnesota show, the speed and success of recovery can be greatly enhanced by establishing processes and relationships before an event occurs. Preparing for recovery prior to a disaster—pre-event recovery planning—reduces the problems of trying to locate required capabilities and create policies when scrambling to



Source: Adapted from the *National Disaster Recovery Framework* (FEMA/DHS 2011).

Figure 1. Traditional recovery phases.

manage immediate recovery. Recovery efforts are executed more efficiently when resources are pre-positioned, contractors have been pre-approved, and alternate facilities are already identified. In addition, recovery can begin quickly without the need to wait until recovery plans are developed after the disaster.

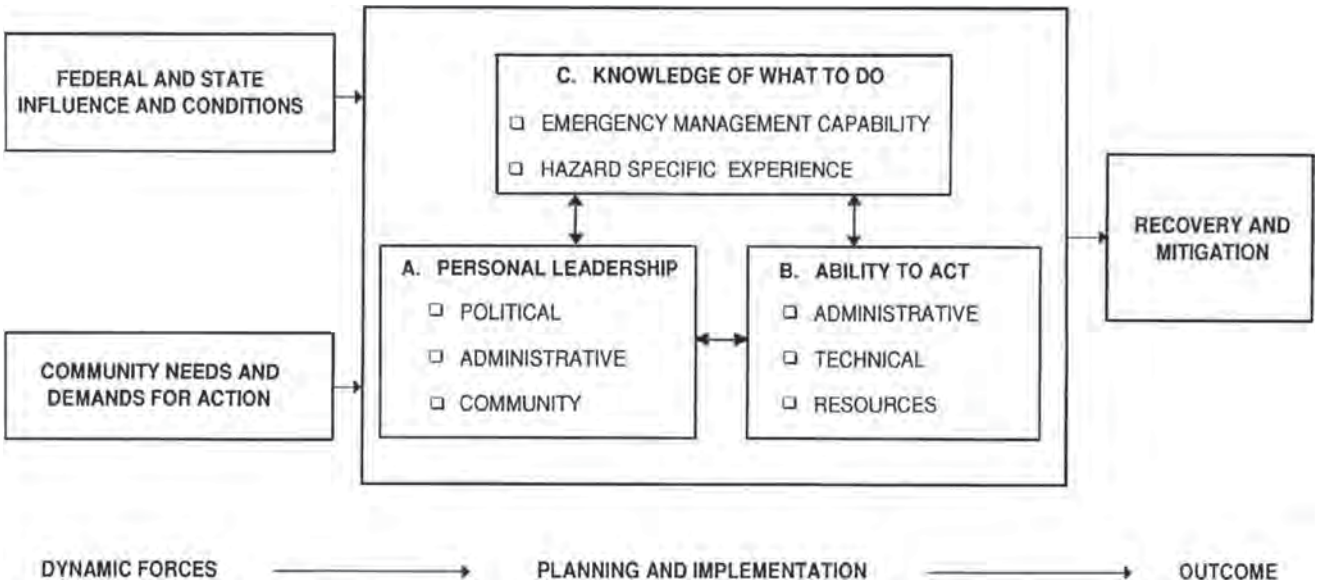
The Government Accountability Office, in the report *Catastrophic Disasters: Enhanced Leadership, Capabilities, and Accountability Controls Will Improve the Effectiveness of the Nation's Preparedness, Response, and Recovery System* (2006), found that preparing for and recovering from any catastrophic incident involves three basic elements: leadership, capabilities, and accountability. Other researchers have found similar key elements that impact the effectiveness of a recovery process: leadership, ability to act, and knowledge of what to do (see Figure 3).

As noted in an overview of *The Recovery Phase of Emergency Management* (Baird 2010) prepared for the Intermodal Freight Transportation Institute:

> From a transportation perspective, many aspects of "emergency management" and "homeland security" have received the attention of governmental agencies and transportation researchers, but recovery is seldom mentioned. Significant initiatives have been undertaken to improve security of the transportation infrastructure and security for passengers and cargo . . . Transportation and public works agencies

Source: Adapted from the *NDRF* (FEMA/DHS 2011).

Figure 2. Recovery as a process.



Source: Adapted from Rubin, Saperstein, and Barbee 1985.

Figure 3. Elements of recovery process.

> have become more active participants in emergency drills and exercises. Public agencies are letting their stakeholders know about improvements in mitigation, preparedness, and response, but searches of publications and websites did not identify a single initiative among public agencies focused exclusively on recovery. (27–28)

NCHRP Report 753: A Pre-Event Recovery Planning Guide for Transportation is created to provide an overview of what can be done to prepare for the recovery of transportation critical infrastructure. Principles and processes based on federal guidance, effective practices, and observations based on case studies are provided to guide transportation owners and operators in their efforts to plan for recovery prior to the occurrence of an event that impacts transportation systems. Tools and resources are included to assist in both pre-planning for recovery and implementing recovery after an event.

CHAPTER 2

Federal Strategies and Initiatives

Federal authorities that guide recovery include national strategies, federal statutes, regulations, executive orders, and presidential directives. The National Strategy for Homeland Security and Emergency Management drives all of the subsequent national directives, initiatives, and common approaches for incident management, response, recovery, and resilience. Figure 4 illustrates the relationship of the strategies, directives, and initiatives.

Presidential Directives

There are three key presidential directives that establish policies and frameworks related to recovery planning.

Homeland Security Presidential Directive (HSPD) 5: Management of Domestic Incidents

HSPD-5, issued February 28, 2003, requires the Secretary of Homeland Security to develop a National Incident Management System (NIMS) that will provide a consistent nationwide approach to incident management for federal, state, and local governments. HSPD-5 also requires the development of a National Response Plan. As of March 22, 2008, the National Response Framework (NRF) (FEMA 2008) superseded the National Response Plan.

Homeland Security Presidential Directive (HSPD) 7: Critical Infrastructure Identification, Prioritization, and Protection

HSPD-7, issued December 17, 2003, mandates the creation of a National Plan for Critical Infrastructure and Key Resources Protection.

Homeland Security Presidential Directive (HSPD) 8: National Preparedness

HSPD-8, issued December 17, 2003, requires the development of a National Preparedness Goal (NPG) and also establishes mechanisms for improved delivery of federal preparedness assistance to state and local governments.

National Frameworks

A number of national frameworks and strategies have been established with relevance to recovery planning.

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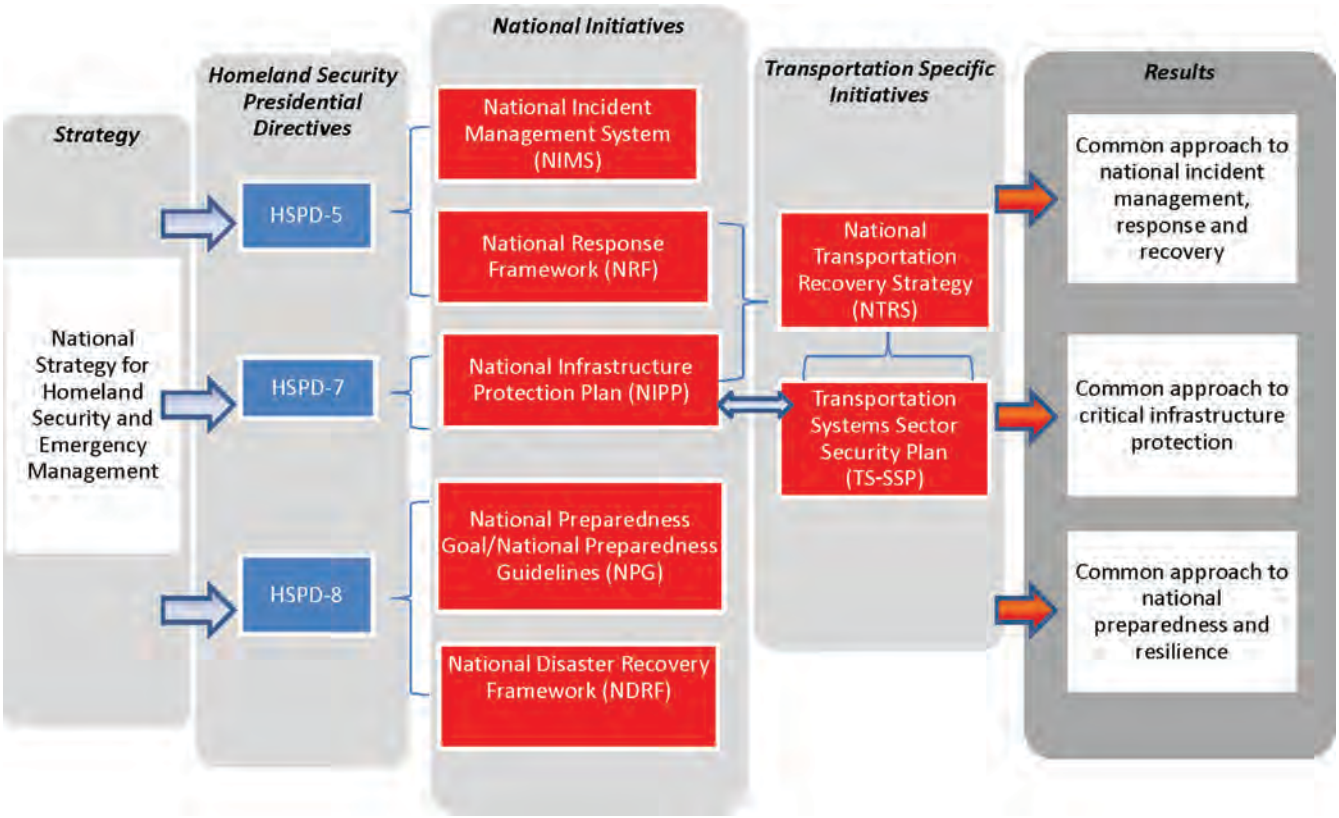

Source: Adapted from Wallace et al. 2010.

Figure 4. National disaster recovery management policies and guidelines.

National Incident Management System

The NIMS provides a systematic, proactive approach to guide departments and agencies at all levels of government, nongovernmental organizations, and the private sector to work seamlessly to prevent, protect against, respond to, recover from, and mitigate the effects of incidents, regardless of cause, size, location, or complexity, in order to reduce the loss of life and property and harm to the environment.

Under NIMS, a series of Emergency Support Functions (ESFs) have been established. Three of these ESFs have particular relevance to pre-event recovery planning: ESF #1: Transportation, ESF #3: Public Works and Engineering, and ESF #14: Long-Term Recovery.

Under ESF #1, U.S. DOT provides assistance that includes the coordination of the restoration and recovery of transportation infrastructure beyond the state and local level; the prioritization of restoration efforts based on needs; and funding sources and technical experts (e.g., inspectors, engineers, etc.) that can be utilized to support restoration and recovery efforts.

Under ESF #3, federal public works and engineering support is provided when additional resources or capabilities to support the response and initial recovery are required. Activities include providing coordination and technical assistance for the rapid recovery and reconstitution of critical waterways, channels, and ports (e.g., vessel removal, significant marine debris removal, and hydrographic survey). In coordination with community recovery activities under ESF #14, ESF #3 implements funding under FEMA's Public Assistance (PA) Program to permanently repair, replace, or relocate damaged or destroyed public facilities and infrastructure including transportation infrastructure.

ESF #14 includes the coordination of national long-term recovery strategies and plans with other relevant federal departments and agencies that have independent authorities and responsibilities for addressing key issues regarding catastrophic incidents. These may include contaminated debris management, decontamination and environmental restoration, and restoration of public facilities and infrastructure. Also included is pre-incident planning and coordination including encouraging primary and support agencies to meet regularly at the national and regional levels to ensure that procedures and program/contact information are up-to-date, to discuss lessons identified from incidents and exercises, and to explore ways to leverage resources through creative use of federal assistance.

National Response Framework

The NRF provides guiding principles to prepare for and provide a unified response to disasters. The NRF establishes a comprehensive, national, all hazards approach to domestic incident response for the full range of incidents up to national catastrophes. It builds upon the NIMS. While the NIMS provides the template for the management of incidents, the NRF provides the structure and mechanisms for incident management policy at the national level.

National Infrastructure Protection Plan

The National Infrastructure Protection Plan (NIPP) provides a coordinated approach to establish national priorities, goals, and requirements for Critical Infrastructure and Key Resources (CIKR) protection. The NIPP specifies the key initiatives, milestones, and metrics required to achieve the nation's CIKR protection mission. NIPP sets forth a comprehensive risk management framework and clearly defined roles and responsibilities for the Department of Homeland Security (DHS); federal Sector-Specific Agencies (SSAs); and other federal, state, local, tribal, territorial, and private-sector partners.

National Disaster Recovery Framework

The NDRF outlines how community recovery is supported on a national level. The NDRF defines key roles and responsibilities of local, state, tribal, and federal governments, the private sector, and voluntary, faith-based, and community organizations in recovery. It captures resources, capabilities, and effective practices for recovering from disaster, recognizing that significant challenges can confront all recovery efforts, from a relatively localized event to a large-scale disaster that demands substantial resources. Once finalized, the NDRF is intended to be the companion document to the NRF issued in January 2008.

At the President's request, the Secretaries of Homeland Security and Housing and Urban Development are co-chairing a Long-Term Disaster Recovery Working Group composed of the Secretaries and Administrators of more than 20 departments, agencies, and offices. This high-level, strategic initiative will provide operational guidance for recovery organizations as well as make suggestions for future improvement.

National Preparedness Guidelines

The DHS published the *National Preparedness Guidelines* in 2007 to help entities at all levels of government build and maintain the capabilities to prevent, protect against, respond to, and recover from major events in order "to minimize the impact on lives, property, and the economy." To do this, the *National Preparedness Guidelines* provide readiness targets; priorities; standards for assessments and strategies; and a system for assessing the nation's overall level of preparedness across four mission areas: prevention, protection, response, and recovery.

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There are four critical elements of the *National Preparedness Guidelines* (DHS 2007):

1. The National Preparedness Vision, which provides a concise statement of the core preparedness goal for the nation: "A nation prepared with coordinated capabilities to prevent, protect against, respond to, and recover from all hazards in a way that balances risk with resources and need."
2. The National Planning Scenarios, which depict a diverse set of high-consequence threat scenarios of both potential terrorist attacks and natural disasters. Collectively, the 15 scenarios are designed to focus contingency planning for homeland security preparedness work at all levels of government and with the private sector. The scenarios form the basis for coordinated federal planning, training, exercises, and grant investments needed to prepare for emergencies of all types.
3. The Universal Task List (UTL), which is a menu of some 1,600 unique tasks that can facilitate efforts to prevent, protect against, respond to, and recover from the major events that are presented in the National Planning Scenarios. The UTL presents a common vocabulary and identifies key tasks that support the development of essential capabilities among organizations at all levels. No entity is expected to perform every task.
4. The Target Capabilities List (TCL), which defines 37 specific capabilities that communities, the private sector, and all levels of government should collectively possess in order to respond effectively to disasters.

Transportation-Specific National Initiatives

Transportation Systems Critical Infrastructure and Key Resources Sector-Specific Plan (TS-SSP)

The TS-SSP is one of 17 SSPs under the NIPP. The goals of the TS-SSP are to:

- Prevent and deter acts of terrorism against the transportation system;
- Enhance the resilience of the transportation system; and
- Improve the cost-effective use of resources for transportation security.

The TS-SSP includes goals, actions, and approaches for properly implementing the plan, along with descriptions of the challenges related to the plan's application. The plan covers the six key transportation subsectors—Aviation, Maritime, Mass Transit, Highway, Freight Rail, and Pipeline.

National Transportation Recovery Strategy

The National Transportation Recovery Strategy (NTRS) addresses transportation recovery and resiliency in communities and provides an overview of incident management with an all hazards approach. The NTRS covers recommendations for preparing and managing the transportation recovery process and briefly explains the federal government's role and funding mechanisms in transportation recovery. This information will be further outlined with tools and resources in an upcoming web guide. The purpose and goal of the NTRS is to help government officials and transportation industry stakeholders prepare for or manage the transportation recovery process following a major disaster, while promoting a recovery process.

The NTRS provides recommendations on how to prepare for and manage the transportation recovery process for the private transportation industry stakeholders, local government, and state/tribal governments. Figure 5 provides an overview of the key recommendations provided in the NTRS.

- Establish clear leadership, coordination, and decision-making structures at local, state and tribal levels.
- Develop pre-disaster partnerships to ensure engagement of all potential resources through the following methods:
  - Identifying and engaging stakeholders including, but not limited to, the general public, community leaders, faith-based organizations, nonprofit organizations, and private-sector entities.
  - Organizing connections to interface with local, state, tribal and federal governments.
  - Ensuring community participation of historically underserved populations including diverse racial and ethnic communities, individuals with disabilities, others with access and functional needs, children, seniors, and individuals with limited English proficiency.
- Test and evaluate pre-disaster plans through seminars, workshops, and exercises.
- Build partnerships between neighborhoods and local government agencies to form the basis for pre- and post-multihazard assessments and support for mitigation actions.
- Integrate pre-disaster recovery planning (e.g., response, land use, and hazard mitigation planning) with other appropriate community planning (e.g., comprehensive, accessibility design, and capital improvement planning).
- Identify limitations in community recovery capacity and the means to supplement this capacity.
- Incorporate sustainable development including environmental, historic preservation, and financial elements into recovery planning guidelines.
- Develop an accessible public information campaign that addresses the concerns of the public and an array of possible scenarios.
- Prepare pre-disaster memoranda of understanding (MOUs) as a way to establish early partnerships, planning initiatives, and expectations with stakeholders, community faith-based organizations, nonprofit groups, and private-sector entities.
- Develop and implement recovery training and education as a tool for building recovery capacity and make it available to all other stakeholders.
- Identify resource requirements and conduct acquisition planning.

Source: U.S. DOT 2009.

Figure 5. NTRS key recommendations.

CHAPTER 3

Principles of Pre-Event Recovery Planning

Planning for recovery (pre-event planning) is an integral part of preparedness, as illustrated in Figure 6. Along with mitigation planning and response planning, preparing for the recovery from an event can be done prior to the event. Such planning can potentially reduce the time and effort involved in recovery and provides opportunities to assess the potential effects of an event and identify mitigation strategies to reduce its consequences.

A number of principles should be taken into account when embarking on a pre-event recovery-planning process. If these principles are employed properly, they will help ensure that the recovery is conducted quickly, efficiently, and cost-effectively while limiting negative disruptions and improving the infrastructure after the recovery. The principles are not exhaustive, but represent overarching tenets and practices identified through the case studies and current industry resources. The principles are listed below:

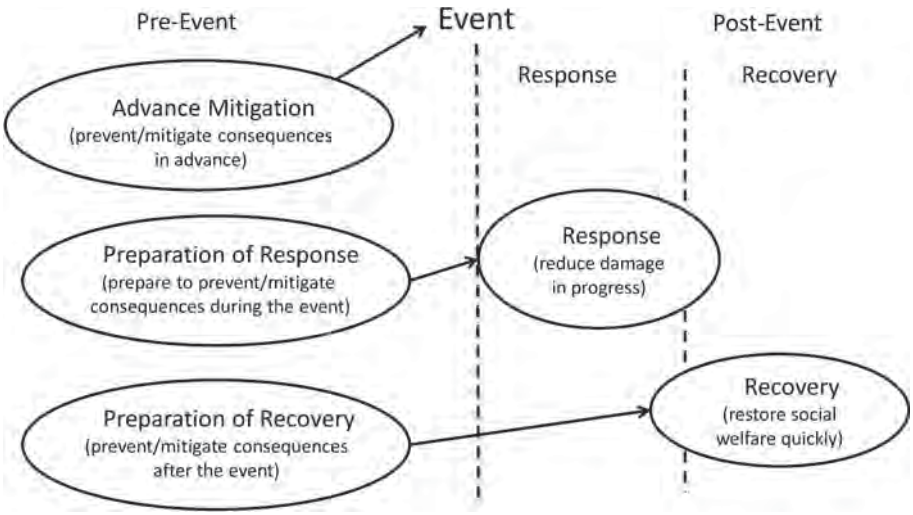
- Recovery Is Different from Response
- Response Can Impact Recovery
- Short-Term Approaches Have Impact on Long-Term Recovery
- Rebuilding Is an Opportunity to Improve Infrastructure and Incorporate Resilience
- Economic Impact Is a Part of Recovery
- Take a Collaborative Approach
- Take a Regional Approach
- Establish Priorities in Advance
- Organize Roles and Responsibilities
- Be Aware of Funding Realities
- Link the Pre-Event Recovery Planning to Other Plans
- Incorporate Flexibility and Identify Alternatives

Discussion of each principle follows.

Recovery Is Different from Response

The distinction between recovery and response is important. The skills, resources, objectives, time horizons, and stakeholders of the response and recovery phases are dramatically different. Having a recovery plan is different from just modifying or adding on to the existing emergency response plans. As summarized in *Introduction to Emergency Management* (Haddow, Bullock, and Coppola 2008):

> Unlike the response function, where all efforts have a singular focus, the recovery function or process is characterized by a complex set of issues and decisions that must be made by individuals and communities. Recovery involves decisions and actions relative to rebuilding and replacing property, resuming employment,



Source: Leonard and Howitt 2009.

Figure 6. Pre-event planning and preparedness.

> restoring businesses, and permanently repairing and rebuilding infrastructure. The recovery process requires balancing the more immediate need to return the community to normalcy with the longer term goal of reducing future vulnerability. (213)

Emergency situations will generally bring together diverse experts who may not work together on non-emergency infrastructure construction projects. To quickly and efficiently implement disaster recovery, a recovery organization with clear authority and responsibilities needs to be identified prior to the event. According to effective practices, the team should be involved in the planning process and, given the demands of recovery operations, should be separate from the emergency response organization. The recovery team members need to understand what their responsibilities are and how they interact with the emergency response team and others involved in recovery.

Response Can Impact Recovery

It is important to understand that the response and recovery phases often overlap and that response efforts have an impact on recovery. Research has found that quick response to an event that damages infrastructure can mitigate the losses and speed up the time necessary to recover. For example, if assessing damage and clearing away debris can be done quickly, the infrastructure recovery process will begin sooner.

Another key issue is how quickly the recovery team can begin work at incident locations. Providing access to critical locations while the response effort is still in progress can expedite the recovery. For example, after all survivors were led to safety during the July 7, 2005, London Transit Bombing Event (approximately 4 hours after the rescue teams arrived), planning for the recovery became part of the incident team's consideration. The London Underground Recovery Team was given space to begin its project management activities, such as planning for structural surveys and determining the specific equipment needed for the recovery. Access arrangements were made for the structural engineers so that they could determine damage. Permission was granted for equipment needed, and plans were made to bring in equipment such as large cranes in a manner that did not interfere with the investigation.

Short-Term Approaches Have Impact on Long-Term Recovery

Short-term recovery decisions can have long-term implications. For example, bridge closures, locations selected for debris sites, and decisions about infrastructure restoration can limit longer term options. Some of the long-term recovery activities are extensions of short-term activities, such as making permanent repairs to structures that have been temporarily reinforced to mitigate damage. Other long-term efforts begin after short-term tasks of debris removal and restoration of at least minimal service capacity have been completed. Identifying in advance the decisions with the potential to have the most influence on long-term plans and addressing them through pre-event planning can help maintain the balance between short-term and long-term recovery measures.

Rebuilding Is an Opportunity to Improve Infrastructure and Incorporate Resilience

An effective recovery process includes not only repairing and rebuilding damaged infrastructure, but also rebuilding infrastructure in a way that reduces future risks. Planning for recovery provides the opportunity to assess potential effects of an event, use improved construction methods and materials, and identify mitigation strategies to reduce risks.

Incorporating hazard mitigation into pre-event recovery plans enables communities to "seize opportunities for hazard mitigation that arise in the aftermath of a disaster," as pointed out in *Planning for Post-Disaster Recovery and Reconstruction* (Schwab et al. 1998). As also noted in the report:

> Pre-disaster and post-disaster mitigation should be two parts of a seamless whole in a sound plan of post-disaster recovery and reconstruction. The only difference, although it is often a major difference, is one of scale of accelerating the pace with which existing mitigation plans are implemented, as a result of the influx of outside assistance. (62)

Infrastructure matters. As found in the work being done to update *Planning for Post-Disaster Recovery and Reconstruction* (Schwab et al. 1998), "Planning for Post-Disaster Recovery: Next Generation":

> Hazard mitigation planning must studiously inventory our infrastructure vulnerabilities, including paths for water to flood subway systems, airports near the waterfront that may become inoperative, railroad tracks that will be underwater, etc. The nation's underinvestment in infrastructure takes its toll in these situations, but so does a lack of attention to mitigation when we make such investments. (J. Schwab, "Reacting to Sandy," APA Recovery News, http://blogs.planning.org/postdisaster/2012/10/31/reacting-to-sandy/)

Economic Impact Is a Part of Recovery

Transportation systems are critical to a community's economic recovery. Along with the transport of critical goods and services, transportation networks provide access to workplaces and commercial businesses. The extended disruption of these systems can have a catastrophic impact on a region's economic health. Understanding community economic needs is important and should be incorporated into transportation pre-event recovery planning.

Economic considerations need to be considered when prioritizing recovery. Pre-event planners should consider the roles of business and economic development entities in the pre-planning and recovery process. Inclusion of these groups will allow the accurate identification of the most important economic connections in the recovery. Additionally, current infrastructure economic coordination planning structures (Transportation Improvement Programs, Metropolitan

Planning Councils, etc.) are pre-existing and effective tools for helping planners identify economic priorities.

Additionally, planners must be mindful of the need to provide temporary services that replace disrupted service in the short term to ensure that economic impacts are mitigated. For example, after Hurricane Katrina, a new transportation service that brought displaced workers back to New Orleans for work was established to help the city recover economically. The service was funded by FEMA and coordinated with the Federal Transit Administration, State of Louisiana, and New Orleans Regional Transit.

Take a Collaborative Approach

Emergency recovery situations bring together people who may not work together during non-emergency situations. The goal of collaboration is to combine knowledge, expertise, and information across agencies and jurisdictions to create procedures and communications processes to improve recovery. Establishing and reinforcing these relationships before an event provides the opportunity to build understanding of each other's needs during recovery. Better working relationships also lead to better coordination, which in turn yields better recovery results and fewer delays.

Take a Regional Approach

A best practice for recovery planning is to coordinate regionally. Major events often have a regional impact. As the State of Florida *Post-Disaster Redevelopment Planning: A Guide for Florida Communities* (Florida Department of Community Affairs and Florida Division of Emergency Management 2010) notes,

> After a major disaster, smaller communities will be dependent on the ability of larger communities that are home to regional infrastructure systems to recover quickly and efficiently before they can recover. The speed of restoration for facilities such as international airports and seaports, and infrastructure such as bridges and truck routes in neighboring jurisdictions can greatly impact the timing of . . . recovery. In addition, some communities will become host to long-term evacuees from neighboring jurisdictions, which may require increased infrastructure capacity. (79)

In addition, large recovery efforts may have an adverse impact on the availability of local management, engineering, and contracting resources that would normally be available, and regional joint planning helps efficiently identify and prepare supplementary support resources.

Establish Priorities in Advance

Given competing demands, limited resources, and the urgency of the recovery effort, establishing recovery priorities and agreeing on trigger-setting processes before an event is essential to avoiding conflicts and delays during the recovery process. When there is scarce capacity, it is important to determine how and when to use it. The priorities established beforehand will guide decision-making during the actual recovery process and should minimize any unintended consequences or conflicts since the recovery team will be working toward established goals.

Another benefit of identifying priorities in advance is the opportunity it affords to ensure that the transportation system owner's recovery priorities are aligned with the community's recovery priorities. Examples of priorities include the following:

- **Organizational goals.** What critical facilities and assets are necessary to provide required service levels? What temporary measures can be taken to enable getting back to normal quickly

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while working on long-term fixes? How much redundancy can be provided to support the service levels required?
- **Economic recovery goals.** What specific transportation requirements are parts of the community recovery plan? What facilities are required to support economic recovery?
- **Long-term planning goals.** What long-term projects have been planned to improve the transportation network? What projects have been considered to increase the resiliency of the transportation system?

Organize Roles and Responsibilities

To quickly and efficiently implement a disaster recovery plan, a recovery organization with clear authority and responsibilities needs to be identified prior to the event. According to effective practices (identified in this Guide), the recovery team should be involved in the planning process and, given the demands of recovery operations, should be separate from the emergency response organization.

The recovery team needs to understand what their responsibilities are and how they interact with the emergency response team and others involved in the recovery. According to the NTRS, as part of the recovery process, transportation owners and operators may be asked to take on specific responsibilities along with the responsibilities of their own business recovery needs. These responsibilities include the following:

- Identify critical facilities, such as hospitals, during the initial response and recovery phases and provide these facilities with critical transportation resources.
- Conduct damage assessments on the transportation service, system, or infrastructure, and determine the impact this damage has on the overall transportation network.
- Provide subject-matter expertise to advise government decision-makers during the recovery phase.
- Implement improved materials and construction methods to prevent similar damage from occurring again.

Appointments to the recovery team should be identified prior to the event so that members of the team can all understand their role in the recovery process and the actions they are expected to perform during the recovery period. This team may include transportation planners, transportation engineers, emergency management experts, environmental experts, and first responders. The team should include members that have experience responding to disasters.

Be Aware of Funding Realities

It is important to know in advance the federal, state, and private resources available to fund any recovery effort and understand any eligibility or documentation requirements for obtaining the funding. Staff with knowledge of financial resources should be included as part of the pre-event recovery planning team to ensure that disaster assistance is effectively utilized.

Link Pre-Event Recovery Planning to Other Plans

Many other plans are already being created: hazard mitigation plans, asset management plans, business continuity plans or COOPs, and emergency management plans. There may even be regional, corridor, and state recovery plans already in place. Transportation recovery planning can be incorporated into those existing plans where appropriate; it does not have to be a separate document to be effective. For example, the California State Emergency Plan includes a Recovery

section that Caltrans helped to develop, and the Caltrans Hazard Mitigation Plan includes recovery by taking an all-aspects approach to emergency management. It is important to integrate pre-disaster planning with other appropriate community planning such as hazard mitigation planning, comprehensive accessibility design, and capital improvement planning.

Incorporate Flexibility and Identify Alternatives

Things happen fast in emergency situations and may not follow a well-planned process, so it is important to make flexibility and duplication a part of the recovery process and develop mechanisms that can be adapted. A dilemma in recovery planning is how to balance achieving fast results with making lasting improvements. The transportation system's recovery goals are often to rapidly return to normal, incorporate mitigation plans for the future, and include long-term system improvements, all of which may not be attainable at the same time. Pre-event recovery planning must consider the flexibility needed to address the differences and potential conflicts between short-term recovery goals and long-term recovery/reconstruction.

CHAPTER 4

Case Studies of Infrastructure Recovery: Lessons and Effective Practices

The limited guidance on pre-event planning for recovery of transportation systems required a compilation of observations from case studies of infrastructure recovery. Under NCHRP Project 20-59(33), five case studies were done that represent a cross-section of infrastructure owners and operators. Table 1 provides an overview of these case studies along with the rationale for the selection of each case for study. The complete NCHRP Project 20-59(33) case studies are provided in Appendix B. In addition to the case studies conducted in this research, existing transportation infrastructure recovery case studies, identified through a literature search, were reviewed and are summarized in Table 2. Effective practices for transportation recovery are compiled in Table 3.

Also included is a case study based on a few forward-looking jurisdictions that have instituted policies, programs, and tools that can assist in recovery. The states of Michigan, Vermont, and Montana were selected because these states represent examples of the importance of driving asset management with a well-defined strategic planning process that incorporates recovery planning.

Michigan's House Bill No. 5396 provides for annual appropriations to support and implement a statewide asset management program. Michigan Department of Transportation (MDOT) has instituted an agency-wide asset management program and introduced an integrated decision-support tool called the Transportation Management System (TMS). The General Assembly of Vermont recently passed Sections 24 and 25 of Act No. 64, which requires the Vermont Agency of Transportation (VTrans) to develop an asset management system that institutes a performance-driven and decision-making process for maintaining, upgrading, and operating transportation assets cost-effectively. In Montana, asset management is tightly linked to strategic planning without formal legislative, budgetary, or funding linkages.

Lessons from the NCHRP Project 20-59(33) case studies are the following:

- Formal and informal relationships and networks were keys to successful recovery.
- Simplified designs can expedite reconstruction.
- Make infrastructure improvements where possible.
- Take a phased approach to recovery.
- Use existing plans and footprints where possible.
- Have emergency expedited processes in place.
- Take a collaborative approach to recovery.
- Use innovation in project development, oversight, and environmental management.
- Understand interdependency of critical infrastructure as part of the hazard and risk assessment.
- Maintain and provide access to designs, plans, and other key data.

Table 1. Case studies conducted under NCHRP Project 20-59(33).

Incident	Synopsis	Rationale
7/7 Bombing, London, United Kingdom, 2005	Four separate but connected explosions occurred on the public transport system in central London, creating an unprecedented cumulative effect.	The London Bombing was a multimodal transportation event that had a rather far-reaching effect on transportation in London for a period of time. The incident provides an opportunity to explore integrated processes and effective practices from an international perspective.
9/11 World Trade Center Attack and Rebuilding, New York/New Jersey, United States, 2001	Attack on World Trade Center and collapse of buildings destroyed New York City transportation infrastructure.	The attack on the World Trade Center in 2001 provides an opportunity to explore the infrastructure rebuilding efforts that have occurred since the event such as the Permanent PATH Terminal and Transit Center and South Ferry Terminal Station.
Midwest Floods, United States, 2008	Flooding in large areas of Missouri and Arkansas and parts of southern Illinois, southern Indiana, southwestern Ohio, and Iowa disrupted major east-west shipping routes for trucks and the east-west rail lines through Iowa.	Exploring the 2008 floods provides an opportunity to understand what changes and improvements have been made on the basis of what has been learned from previous flooding events. For example, in 2008, the Coast Guard Marine Transportation System Recovery Unit developed plans to use the Missouri and Illinois rivers as alternatives for commercial vessel inland water traffic because floods in the past have caused closures on the Mississippi.
Howard Street Tunnel Fire, Baltimore, Maryland, United States, 2001	A CSX freight train derailment shut down Baltimore, disrupted east coast rail service, and U.S. Internet service. In addition, a water main ruptured causing significant street flooding.	Tunnels present unique recovery issues. Researching the Baltimore Tunnel Fire recovery effort provides an opportunity to address numerous recovery issues including fire damage, flooding, and hazardous material clean-up. Interdependencies and cascading impacts can also be explored.
Wildfires, Southern California, United States, 2007	At least 1,500 homes were destroyed and over 500,000 acres of land burned from Santa Barbara County to the United States–Mexico border.	Wildfires have a major impact on regions and present significant recovery issues not only from fire, but also from the subsequent mudslides that can occur as a direct consequence of the fire.

Table 2. Case studies from literature review.

Event	Summary
Hurricanes Gustav and Ike, 2008	Hurricane Gustav was primarily a wind event with the most prominent effect being widespread electrical outages.
Pipeline Disruption, Hurricanes Gustav and Ike, 2008	On January 14 and 15, 2009, the Southeast Petroleum Disruption and After-Action Workshop was held to review the impacts to petroleum supply in the Southeast following Hurricanes Gustav and Ike.
Flooding, Wisconsin, 2008	As a result of severe rains in June 2008, the Kickapoo River in Gays Mills, Wisconsin, flooded more than 90% of the village and severely damaged more than 50% of downtown homes. In conjunction with FEMA, the village of Gays Mills has developed a Long-Term Community Recovery Plan that contains several transportation projects including the creation of a new “Main Street” to attract commerce. Improvements were also proposed for a section of State Route 131.
I-35 Bridge Collapse, Minneapolis, Minnesota, 2007	On August 1, 2007, the I-35 Bridge in Minneapolis, Minnesota, suddenly collapsed. The rebuilding of I-35 was completed within budget and ahead of time. The community—including community residents, local businesses, civic groups, government representatives from all levels, MnDOT, cultural institutions, educational interests, media, and a contract design team—was broadly involved in the design and rebuilding of the bridge.

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Table 2. (Continued).

Event	Summary
Tornado, I-54, Greensburg, Kansas, 2007	Most of the town of Greensburg, Kansas, was destroyed by an EF-5 tornado on May 4, 2007. One of the key elements in planning a new Greensburg was the location and design of the US-54 freeway. Greensburg city officials approached the Kansas DOT about reconsidering a southern bypass recommended in the 2002 US-54/US-400 Location Design Concept Study. After extensive collaboration with Greensburg community leaders and input from city residents, the Kansas DOT developed a project to relocate US-54 along a route that provided the most desirable mix of visibility, access, and economic development opportunities.
MacArthur Maze Collapse, Oakland, California, 2007	When a gasoline tanker accidentally crashed on the MacArthur Maze, one of the busiest freeway interchange systems in the United States, Caltrans swiftly issued an emergency proclamation and built significant incentives for early completion into the contract. The project was completed over a month ahead of schedule.
Storms and Mudslides, California, 2006	In March and April of 2006, California experienced a series of intense storms, landslides, and flooding in more than 15 counties. As a result of these storms, many roads and highways were severely damaged, particularly as a result of landslides and mudslides.
Blackout, New York City, New York, 2003	In August 2003, in approximately 11,300 signalized intersections located within New York City limits, traffic signal operations lost power because of a blackout. Because the blackout occurred on a Thursday afternoon and power was not fully restored by Saturday, the New York City DOT faced the difficult task of ensuring that traffic signal operations and coordination plans were in full working order for the Monday morning rush hour.
Chlorine Spill, Graniteville, South Carolina, 2005	A railroad chlorine spill in Graniteville, South Carolina, highlighted the need for the documentation of transportation infrastructure to facilitate recovery after an event. The event displaced 5,400 people and killed 9 people. Norfolk Southern Railroad estimated that the total cost would range from $30 million to $40 million (Dunning and Oswalt 2007).
Hurricanes Katrina and Rita, Louisiana, 2005	Hurricanes Katrina and Rita resulted in significant damages to transportation systems within the state of Louisiana. An initial assessment showed that 142 moveable bridges in the state were affected by storms and that nearly 20% were damaged severely enough that they were closed for a period of time to marine and/or vehicular traffic. Additional damages were also sustained by state and local highways and other local roads. Ramps on Interstate Highway 10 were submerged in water from flooding, U.S. Highway 90, which ran between New Orleans and Pascagoula, Mississippi, was essentially destroyed, and an 8-mile section of the Twin Span bridge, which connected New Orleans to Slidell, Louisiana, collapsed into Lake Ponchartrain.
Hurricane Katrina Destruction of U.S. Highway 90 Biloxi Bay Bridge and Bay St. Louis Bridge, Mississippi, 2005	In late August of 2005, Hurricane Katrina destroyed approximately 90% of all structures located within 1/2 mile of the Mississippi coast. The 30-foot storm surge washed away the Bay St. Louis and the Biloxi Bay Bridges in Mississippi. In spite of the widespread emergency, regulations required both bridge reconstruction projects to comply with the standard environmental review process. In both cases, FHWA allowed the use of emergency action procedures (23 CFR 770.131).
FLA I-10 Collapse, Hurricane Ivan, Florida, 2004	On September 16, 2004, Hurricane Ivan struck the Gulf Coast of Florida as a Category 3 hurricane. During the storm, a section of I-10 bridge crossing Escambia Bay collapsed into the water.
I-40 Bridge Collapse Caused by Arkansas River Accident, Oklahoma, 2002	On Sunday, May 26, 2002, a barge veered several hundred feet off course and struck the I-40 Bridge crossing the Arkansas River in Webbers Falls, Oklahoma. The collision compromised almost one third of the bridge, which plunged into the Arkansas River. Land ownership at both ends of the bridge is complex. A parcel is owned by the Cherokee Nation, and a parcel is owned by USACE but managed as a wildlife refuge by the U.S. Fish and Wildlife Service. The bridge reopened to traffic on Monday, July 29, 2002, only 65 days after the accident.
Ice Storm in Canada and Northeastern United States, 1998	A severe freezing-rain storm hit Canada and the northeastern United States the week of January 5, 1998. The storm was notable for the large area it covered, the amount of ice that accreted on trees and structures, and widespread power outages.
Northridge Earthquake, Los Angeles, California, 1994	When a strong earthquake struck the Los Angeles area in January 1994, several highways suffered major damage. Caltrans and FHWA agreed to innovative bidding procedures to speed up the rebuilding process.

Table 3. Effective practices for transportation recovery.

Effective Practices	Illustrations
Planning for Recovery	Illinois DOT (IDOT) implemented a bridge recovery plan based on both earthquake and terrorist threats. To implement the recovery plan, IDOT hired consultants who were assigned specific bridges. If something happens to the bridge, they are to report to the bridge immediately to develop a strategy for recovery. Cited in *Transportation Infrastructure Protection and Emergency Management: State DOT Workshop Results* (AASHTO 2009).
Taking a Regional Approach to Transportation Recovery Planning	The Puget Sound Region has developed a Puget Sound Transportation Recovery Annex (Annex) that supplements the Puget Sound Regional Catastrophic Coordination Plan (Coordination Plan). The Annex provides recommended guidelines for coordinating multijurisdictional regional transportation system recovery in the Puget Sound Region after a catastrophic incident. Similar to efforts in California, Arizona, and Oregon are recognized in *Regional Concept of Transportation Operations: Best Practice*s (IBI 2009).
Collaborative Environment for Recovery Efforts	In Minnesota, the I-35 Bridge project team involved the community extensively in the design and construction of a replacement bridge. A broad collaboration, deliberately carried out to enlist maximum participation, was key to rebuilding the collapsed bridge ahead of schedule and under budget. Cited as best practice in *Recovering from Disasters: The National Transportation Recovery Strategy* (U.S. DOT 2009).
Limiting the Project Scope to Reduce Complexity	When the I-35 Bridge collapsed, MnDOT and FHWA limited the scope of the bridge replacement project to bridge reconstruction early in the process and would not consider revisions to approaches or nearby interchanges until bridge construction was complete. This limited scope eliminated the expanded environmental review and possible controversies that are typical for large construction projects. Cited as effective practice in "Meeting Environmental Requirements After a Bridge Collapse," a study on project management and environmental review (John A. Volpe National Transportation Systems Center 2008).
Flexibility in Applying Transportation Resources Across Jurisdictions	Following Hurricane Katrina, the LA Swift project, a multijurisdictional Louisiana effort, resulted in a free bus service for persons displaced to Baton Rouge who needed to commute to their jobs in New Orleans. This was accomplished through the collaboration of operating and funding agencies and recognition of the importance of transportation to economic recovery. Cited as best practice in *Recovering from Disasters: The National Transportation Recovery Strategy* (U.S. DOT 2009).
Good Working Relationships and Open Lines of Communication	Historically, the Florida Department of Environmental Protection (FDEP) and the Florida DOT (FDOT) in the 16-county region from Tallahassee to the Alabama border have had a strained working relationship. To improve their relationship, the two agencies held quarterly meetings and built trust between the agencies. In the aftermath of Hurricane Ivan and the destruction of the I-10 Bridge, the pre-existing interagency relationships facilitated communication between FDEP and FDOT and allowed state-level environmental permits to be quickly processed. Cited as effective practice in "Meeting Environmental Requirements After a Bridge Collapse," a study on project management and environmental review (John A. Volpe National Transportation Systems Center 2008).
Formal and Informal Emergency Procedures	Hurricane Katrina led agencies to enact a series of formal and informal emergency procedures. These expedited the reconstruction of the U.S. 90 Biloxi Bay Bridge and Bay St. Louis Bridge in Mississippi. In addition to enacting Endangered Species Act (ESA) Section 7 emergency consultations, under the directive of the FHWA Mississippi division office, agencies opened their lines of communication and allowed some verbal agreements instead of standard written agreements. Cited as effective practice in "Meeting Environmental Requirements After a Bridge Collapse," a study on project management and environmental review (John A. Volpe National Transportation Systems Center 2008).

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Table 3. (Continued).

Effective Practices	Illustrations
Innovative Contracting Techniques	Several innovative methods expedited completion of multiple projects after the 1994 Northridge Earthquake in California: A+B bidding (a combination of cost and time), invitational bidding, and design-build bidding. Cited as a best practice in *Recovering from Disasters: The National Transportation Recovery Strategy* (U.S. DOT 2009). Use of design-build contracts expedited the environmental review process for the U.S. 90 Biloxi Bay Bridge and Bay St. Louis Bridge. Since the contractor could proceed before receiving all the necessary permits, reconstruction began quickly. Cited as effective practice in "Meeting Environmental Requirements After a Bridge Collapse," a study on project management and environmental review (John A. Volpe National Transportation Systems Center 2008).
Access to Good Data	The Oklahoma DOT, the State Historical Preservation Office (SHPO), and the Oklahoma State Archeologist had taken (inventories of natural, cultural, and historic resources through ODOT's Cultural Resources Program in the Arkansas River area, which helps identify potential cultural and historic sites that may require special attention as part of highway projects. When the I-40 Bridge accident occurred, these agencies were able to immediately identify potential natural and historic issues, eliminating the need for additional investigation and studies to identify and understand any potential environmental problems for the reconstruction project. Cited as effective practice in "Meeting Environmental Requirements After a Bridge Collapse," a study on project management and environmental review (John A. Volpe National Transportation Systems Center 2008).
Incorporating Long-Term Community Recovery Goals	After a 2007 tornado destroyed the town of Greensburg, Kansas, the Kansas DOT reconsidered the long-term plan for I-54 based on community recovery goals because the location of the future freeway affected community rebuilding plans. A relocated route was developed because it provided the most desirable mix of visibility, access, and economic development opportunities for the community. Cited as best practice in *Recovering from Disasters: The National Transportation Recovery Strategy* (U.S. DOT 2009).
Coordinated and/or Standardized Damage Assessments	The Wisconsin DOT (WisDOT) serves as the coordinating agency for infrastructure damages in the state. June 2008 Midwest flooding provides example. Caltrans has established a Safety Assessment Program (SAP) to quickly produce damage assessments after an event.

- Plan for the unexpected by learning from previous experiences.
- Integrate recovery planning with existing planning.

Each lesson, with specific illustrations from the case studies, is discussed below.

Formal and Informal Relationships and Networks Were Keys to Successful Recovery

Based on experiences from past disaster events, Iowa DOT now works closely with multiple federal agencies as a part of the recovery process. For instance, Iowa DOT functions as the coordinator for the FHWA Emergency Relief (ER) program and is responsible for processing the Detailed Damage Inspection Report (DDIR).

Recovery from the 9/11 incident in New York City was made possible by using pre-existing relationships, including those with retired personnel and volunteers. In the London 7/7 bombings, the fact that personnel knew each other played a very important role in coordination.

In California, a multi-agency working group composed of key asset owners and stakeholders coordinates planning and implementation.

Simplified Designs Can Expedite Reconstruction

After 9/11, lack of architectural detail in the temporary Port Authority Trans-Hudson Corporation (PATH) stations allowed bidding on the necessary steel on a per-pound basis before the design was even finished. The conduit carrying the utilities and cabling was left exposed, eliminating the design time needed to artfully bury it. These strategies shaved 1 year off the construction schedule.

Make Infrastructure Improvements Where Possible

Bench walls, lighting, and communication enhancements in PATH tunnels after 9/11 in New York City were added during recovery construction. The Baltimore tunnel case study noted the need for upgrading aging infrastructure as part of the rehabilitation of critical infrastructure.

Take a Phased Approach to Recovery

After 9/11, PATH service to lower Manhattan was provided through a series of temporary transit stations and entrances.

Use Existing Plans and Footprints Where Possible

To restore train service to the World Trade Center site as quickly as possible, a temporary PATH terminal was built at the same location as the destroyed facility. This enabled engineers to utilize previous alignments and reduce additional excavation/foundation work.

Have Emergency Expedited Processes in Place

The California governor's declaration of disaster can ease environmental requirements and other contracting requirements. Emergency contracts can be rapidly implemented using a ready list of pre-identified and pre-qualified contractors, even before federal funding is available.

Take a Collaborative Approach to Recovery

After 9/11, collaboration with contractors and designers was part of design and construction. For instance, the sequence of construction inside the tunnels was done differently, in a process developed in conjunction with the contractor, who wanted to use rubber-tired equipment to bring in materials. The contractor's desired approach required locating everything first and then laying the track last. To accommodate this, a high level of survey control was developed along with a "clearance jig" to make sure the trains had enough clearance.

Use Innovation in Project Development, Oversight, and Environmental Management

After 9/11, FTA's Lower Manhattan Recovery Office (LMRO) was created to work on innovative, streamlined project delivery processes with consensus among federal and local partners. Some of these processes included using one grant for the entire project, developing a master agreement

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for both FTA and FEMA requirements, creating a memorandum of understanding (MOU) among federal agencies for environmental oversight, and creating a Federal Interagency Review Team.

Understand Interdependency of Critical Infrastructure as Part of the Hazard and Risk Assessment

The Baltimore tunnel case study illustrated the interdependencies of transportation, communications, and other critical infrastructure. Asset management systems, as discussed in the case study of Michigan, Montana, Ohio, and Vermont, can address the issue by helping in maintenance of statewide transportation assets and eliminating system deficiencies.

Maintain and Provide Access to Designs, Plans, and Other Key Data

After 9/11, the availability of designs, plans and other data became an issue because key plans and documents were stored in the World Trade Center. Key tunnel documents were not found until days after the incident in the Howard Tunnel in Baltimore. Many roadway and bridge design plans, shop drawings, and other infrastructure record documents are available on a 24-hour basis in Iowa DOT's electronic record management system (ERMS).

Plan for the Unexpected by Learning from Previous Experiences

After the 1993 World Trade Center bombing, every agency and facility put emergency plans in place, but none of these entities was prepared for an event of the enormity and scale of 9/11. Similarly, after the London bombings, planning has been expanded to cover multisite scenarios. For tunnels, water intrusion is a critical issue, and infrastructure interdependencies can be identified.

Integrate Recovery Planning with Existing Planning

Iowa has a State Recovery Plan that includes a Transportation Appendix that details the roles, responsibilities, and framework for post-disaster transportation recovery. In California, the State Emergency Plan includes a Recovery section that Caltrans helped to develop, and recovery is integrated into hazard mitigation planning and COOP efforts.

CHAPTER 5

Key Tasks of Pre-Event Recovery Planning

Fundamentals of Emergency Management (Lindell et al. 2006) lists disaster recovery functions grouped into categories of disaster assessment, short-term recovery, long-term reconstruction, and recovery management, as shown in Figure 7.

NCHRP Report 525: Surface Transportation Security—Volume 16: A Guide to Emergency Response Planning at State Transportation Agencies (Wallace et al. 2010) identified phased recovery tasks that include the following:

- Restoring essential services including conducting damage assessments, removing debris, and providing access for essential services.
- Re-establishing traffic management in affected area by coordinating restoration plans with affected communities and governmental operations.
- Allowing re-entry to affected areas for evacuated residents and others restoring transportation-supporting infrastructure.
- Conduct emergency and long-term repairs such as infrastructure repair, reconstruction, and decontamination.

In addition, recovery "keys to success"—the decisions, actions, and processes that can help expedite the overall recovery process—have been identified in recovery research and case studies of incidents that impacted transportation infrastructure. Figure 8 summarizes the keys to success for emergency management recovery functions most relevant to pre-event recovery planning along with those relating to communications and coordination.

Some of the keys to success listed in Figure 8 are pre-event tasks such as identifying repair and replacement approaches in advance and pre-qualifying contractors. Other keys to success, which can only occur post-event, can be supported by pre-event efforts. For example, critical infrastructure identification and vulnerability assessments can be drawn upon to support the prioritization decisions that must be made during recovery.

Figure 9 summarizes major decisions and key tasks that typically can be done *before* an event to prepare for the recovery of transportation critical infrastructure along with the related post-event tasks. These major decisions and key tasks are based on observations and effective practices. The sections that follow address each decision and related tasks in more detail. Effective practices and recommended approaches are included. Appendix A provides resources including checklists, worksheets, and tools to assist in the process.

An incident involving chemical, biological, or radiological (CBR) agents will result in significant disruption of services. Compared to more common natural disasters, CBR incidents involve unique challenges and require significant operational adjustments. Pre-event planning has been found to be essential in handling these kinds of incidents. Having a restoration plan vetted in advance and facility personnel trained beforehand substantially reduces the overall time for

Disaster Assessment	
Rapid assessment	Needs assessment
Preliminary damage assessment	"Lessons to be learned"
Site assessment	
Short-Term Recovery	
Infrastructure restoration	Emergency demolition
Debris management	Repair permitting
Long-Term Reconstruction	
Hazard source control and area protection	Infrastructure resilience
Land use practices	Historic preservation
Building construction practices	Environmental recovery
Recovery Management	
Agency notification and mobilization	Public information
Mobilization of recovery facilities and equipment	Recovery legal authority and financing
	Administrative and logistical support
Internal direction and control	Documentation
External coordination	

Source: Adapted from *Fundamentals of Emergency Management* (Lindell et al. 2006).

Figure 7. Disaster recovery functions.

restoration and recovery. Appendix D provides more detailed information on decontamination of hazardous materials.

Identification/Prioritization of Infrastructure

- Which infrastructure or key facilities are most at risk?
- What infrastructure is critical to operations and to the community?
- Are there any alternatives available for the infrastructure?

It may not be possible to identify and document every transportation facility or asset or plan for their recovery as the potential impacts can be endless and constantly changing. A

Recovery Keys to Success	
Short-Term Recovery	A phased approach using temporary solutions and multimodal approaches can expedite recovery. Traffic safety, user convenience, and the restoration of economic supply chains depend on timely debris removal and efficient detours.
Long-term Recovery	Effective practices include the following: • Identification of repair and replacement approaches in advance • Pre-qualification of contractors and architects/engineers • Expediting contracting and construction approaches • Incorporating accelerated construction technologies • Maintaining design drawing and specifications Early decisions as to using the "as-built" design or redesigning the structure determine the minimum recovery time achievable.
Recovery Management	Define clear disaster policies and practices in advance. Streamline administration and accelerate the approval process for emergencies. Preparation, planning, and practice involving the parties who will play the major roles in recovery prior to event can expedite recovery.
Communications and Collaboration	Clear and streamlined communications, with coordination and a cooperative attitude among all of the stakeholders in the process is critical. Early information communication among responders, engineers, and all other impacted stakeholders, including the media, is essential.

Figure 8. Recovery keys to success by recovery function.

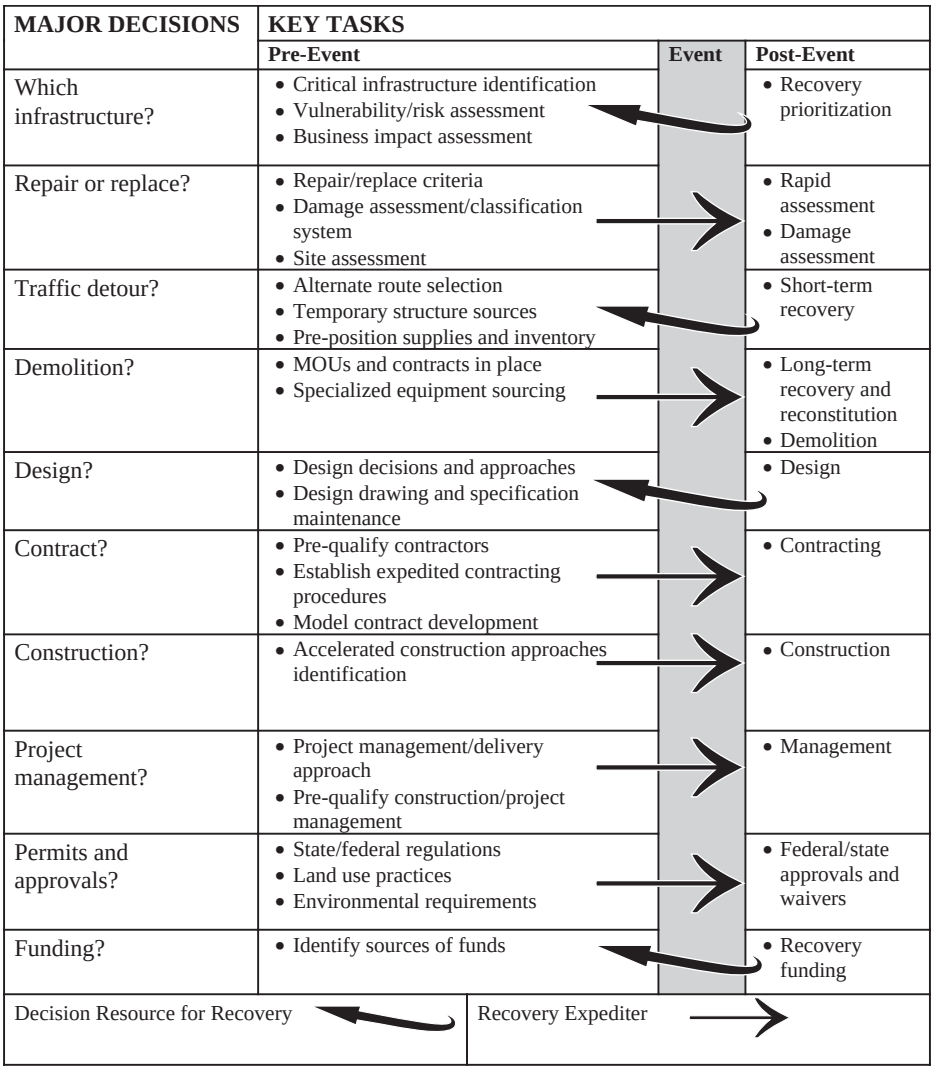

Figure 9. Recovery major decisions and key tasks.

decision process for deciding which facilities should be addressed can be established. Based on review of case studies and research literature, the recommended decision process includes the following:

- **Inventory** of the critical assets in the transportation system and the potential hazards.
- **Assessments** based on risk, consequences, financial impacts, and recovery options.
- **Prioritization** incorporating community needs, operational importance, and business goals.

Transportation assets consist of people, property, and information. This discussion will focus on physical assets—transportation infrastructure, facilities, and vehicles. Critical infrastructure and facilities are those "required to enable the organization to execute its primary responsibilities, activities, and functions" (Frazier, Sr., Nakanishi, and Lorimer 2009). Table 4 provides an overview of pre-event tasks, considerations, and related approaches/plans that can help identify and prioritize critical assets. In addition, AASHTO guidance on assessment and prioritization, National Transportation Recovery Strategy guidance, and an asset management system can help with identification and prioritization of critical assets. Discussion of each of these resources follows.

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Table 4. Critical infrastructure prioritization pre-event tasks and considerations.

Pre-Event Tasks	Considerations	Related Approaches/Plans
Identify critical infrastructure.	Incorporate vulnerability assessments and hazard mitigation planning. Include the concepts of economic development in critical assessment. This is often already done for transportation investment. Take advantage of asset management systems and related tools such as Costing Asset Protection: An All Hazards Guide for Transportation Agencies (CAPTA).	Risk Assessments Hazard Mitigation Plan Long-Range Planning Transportation Improvement Program (TIP) Asset Management System
Identify priorities.	Include operational importance and business goals. Incorporate community and economic goals. Work with Protective Security Advisor (PSA) to determine parts of network that are considered a Tier 1 or Tier 2 asset per the National CIKR Prioritization Program.	Business Impact Analysis Lifelines Identification Long-Term Community Recovery Plan

AASHTO Guidance on Assessment and Prioritization

AASHTO has issued *A Guide to Highway Vulnerability Assessment for Critical Asset Identification and Protection* (Science Applications International Corporation 2002) to assist in identifying and prioritizing critical assets. Along with describing an approach for identifying critical infrastructure assets, *A Guide to Vulnerability Assessment for Critical Asset Identification and Protection* suggests criteria that include conditions, concerns, consequences, and capabilities that can be used to prioritize the identified critical assets. A general listing of the information components to be gathered that can assist in the prioritization processes and a prioritization factors table with relative values for the prioritization factors (based on the survey done for *A Guide to Vulnerability Assessment for Critical Asset Identification and Protection*) is also provided.

National Transportation Recovery Strategy Guidance

The National Transportation Recovery Strategy (U.S. DOT 2009) recommends completing the following actions that can assist in asset prioritization prior to an event:

- **Develop a Business Impact Analysis (BIA)** to determine the financial loss that could incur if the transportation system or infrastructure were to be damaged or destroyed that includes consideration of the economic, logistical, and social impacts on the community. The results of the BIA can assist in the determination and prioritization of critical transportation infrastructure.
- **Develop a COOP** using the results from the BIA that is reviewed, exercised, and enhanced on a regular basis. The COOP can assist in identifying which infrastructure and critical facilities have alternates that can be quickly made available after an event. The COOP annex on "Reconstitution" provides an opportunity to include information on which infrastructure assets might need to be replaced or relocated in the process of resuming normal agency operations.
- **Review Risk Assessments** by working with local emergency management officials to understand what the risks are and their probability of occurrence in your community and on your infrastructure. Information on potential hazards, including probability and possible effects, can be obtained from FEMA, State Emergency Management and Civil Defense Agencies, the

National Weather Service (NWS), the EPA, the U.S. Geological Survey (USGS), the USACE, and the Department of Natural Resources (DNR).

Asset Management System

An asset management system can be used as a tool to document and manage critical assets. The inventories of key infrastructure including roadway and rail segments; bridges, tunnels, and other structures; signage and traffic control devices; communication systems; buildings; and other fixed assets in an asset management system could provide rich and malleable data sets to support recovery. An asset management system could assist recovery pre-planning and accelerate recovery decision-making by

- Identifying and prioritizing critical infrastructure
- Developing an accurate snapshot of the "before" condition
- Facilitating the development of reprocurement guidelines and contracts
- Identifying the potential resilience and lifecycle improvements that could be made to improve the asset during recovery

Although none of the states surveyed for this research have connected their asset management system to pre-disaster planning and recovery, a logical link between the two does exist. This connection has been indirectly identified and explored in several Transportation Research Board reports.

NCHRP Report 551: Performance Measures and Targets for Transportation Asset Management (Cambridge Systematics, Inc., PB Consult, Inc., and Texas Transportation Institute 2006) investigates the current state of practice for the integration of performance measurements in asset management systems. The report establishes categories of performance measurements, one of which is preservation. The applied definition of preservation measurement includes actions required to maintain the asset in a condition of good repair during emergency situations. Preservation is a founding principle of asset management and by prioritizing the preservation of infrastructure and a state of good repair, asset owners can reduce the chance that an incident will cripple or destroy infrastructure. The natural progression of system preservation is the identification and application of specific mitigation that would increase the likelihood that an asset would withstand natural and manmade events.

NCHRP Report 525: Surface Transportation Security—Volume 15: Costing Asset Protection: An All Hazards Guide for Transportation Agencies (CAPTA) (Science Applications International Corporation and PB Consult 2009) provides a guide for developing system-wide budget estimates for an all hazards approach to mitigation rooted in NIMS. It uses asset type and profiles to identify recommended countermeasures and accompanying costs. States that already employ comprehensive and fully integrated asset management systems will have already compiled the necessary information to execute the evaluation program.

NCHRP Report 525: Surface Transportation Security—Volume 16: A Guide to Emergency Response Planning at State Transportation Agencies (Wallace et al. 2010) identifies the need for improving construction and maintenance methods to mitigate risk of failure during emergency events. An asset management system would be a natural tool for implementing this goal.

Repair or Replacement Criteria and Options

- Should the infrastructure be replaced?
- What options are there for repairing the infrastructure?
- Should the infrastructure be relocated?
- Are there historic preservation or environmental concerns that need to be addressed?

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Table 5. Repair/replace pre-event tasks and considerations.

Pre-Event Tasks	Considerations
Identify rebuild versus relocate criteria. **Determine repair/rebuild priorities.**	Consider infrastructure condition, e.g., planning to replace infrastructure identified as marginal or inadequate. Assess impact on network, e.g., repairable structures that restore most of the lost regional networks given higher priority. Address historical preservation requirements when applicable.
Identify potential alternate sites for relocation.	Consider whether re-siting to a reduced-risk location is an option.
Prepare/project cost estimates for replacement and for possible land acquisition, if necessary.	Identify mitigation approaches to incorporate such as seismic retrofitting, elevation changes, and flood proofing. Coordinate with Hazard Mitigation Plans to incorporate hazard mitigation into recovery planning.

When transportation infrastructure is damaged or destroyed during a disaster, the impacted structures will either be repaired or replaced. One of the earliest challenges to recovery is gaining an understanding of the extent of damage and what is required to repair and restore the damaged infrastructure. Establishing the repair/replace criteria before an event occurs can expedite the recovery.

Although damage assessments can only be conducted after an event, becoming familiar with the assessment process and who is responsible provides a head start on the recovery process. Multiple organizations—from state and local DOTs to federal regulatory agencies—are likely to be involved in damage assessment, and each may have their own methodology and timeframe requirements. Table 5 provides an overview of pre-event tasks and considerations that can assist in repair/replacement of critical assets. Appendix C provides more information on damage assessment and what can be done prior to an event to help expedite the recovery process. Discussed below are three effective pre-event practices for expediting repair/replacement of critical assets in the event of a disaster: making pre-event decisions on marginal/inadequate infrastructure, use of "What If" templates, and documentation of repair/replacement criteria in the Reconstitution Annex of COOP.

Making Pre-Event Decisions on Marginal/Inadequate Infrastructure

For infrastructure already identified as marginal and inadequate, repair or replacement decisions can more easily be made prior to an event. The "Transportation Recovery Annex: Catastrophic Disaster Coordination Plan" (2011), developed by transportation stakeholders in the Washington State region, includes this recommendation that can apply to other states and regions:

> Many jurisdictions have identified marginal or inadequate structures (e.g., bridges that create traffic bottlenecks, bridges that will need to be replaced, addition of bike lanes or high occupancy vehicle lanes on bridges, etc.) that may need future improvements or additional capacity. In an effort to expedite recovery, local jurisdictions should prepare design/build requests for proposals (RFPs) that can be issued quickly after a major disaster for structures that may need replacement. (X-6)

Use of "What If" Templates

While all potential repair/replacement approaches cannot be identified in advance, the process of asking "what if" questions provides opportunities to discover innovative solutions. London

Transit planners use a series of "considerations" or templates of options to consider instead of creating the more commonly used decision trees. Each template provides the pros and cons for potential approaches or actions for different scenarios. The templates provide the benefit of thinking through the consequences before an event occurs. The information from the templates can support faster recovery through more informed, and as a result, more effective decisions.

Documentation of Repair/Replacement Criteria in the Reconstitution Annex of COOP

As part of COOP, the annex on reconstitution is an opportunity to include information on which infrastructure assets might need to be replaced or relocated in the process of resuming normal agency operations. FEMA has produced *Reconstitution Plan/Annex Template and Instructions* (National Continuity Programs 2011), which provides structure and recommended content for developing a Reconstitution Plan/Annex. Reconstitution Level 3 (Long-Term Planning) is focused on cases in which a facility has been severely damaged or damaged beyond repair. Organizations are encouraged to tailor their Reconstitution Plan/Annex to meet their specific continuity planning and operational needs.

Temporary Structure/Traffic Detour: Short-Term Recovery

- What options are there for traffic detours?
- Can a temporary structure be used? What temporary structures are available?
- What actions can be taken now to prepare?

Taking a phased approach to recovery such as using temporary solutions and considering multimodal approaches was found to expedite recovery. Short-term recovery efforts often overlap with response and focus on providing essential services and re-establishing critical transportation routes. Short-term solutions may provide a longer term redundancy, increasing the resiliency of the transportation network going forward, an approach recommended in the NTRS.

Short-term recovery decisions can have long-term implications. For example, bridge closures, locations selected for debris sites, and decisions about infrastructure restoration can limit longer term options. Often long-term recovery efforts can only begin after short-term tasks, such as restoration of at least minimal service capacity, have been completed. Identifying in advance the decisions with the potential to have the most influence on long-term plans and addressing them through pre-event recovery planning can help maintain the balance between short-term needs and long-term recovery goals. Table 6 provides an overview of pre-event actions and considerations that can assist in determining short-term recovery options such as repair or temporary replacement of critical assets. Effective practices discussed below are establishing traffic mitigation and prioritization in advance, pre-positioning of supplies, and maintaining a supply of temporary structures and developing a policy for their use.

Establishing Traffic Mitigation and Prioritization in Advance

Transportation mitigation strategies can be grouped into categories based on the objectives and methods of the strategy such as increasing capacity on existing lanes, using technology to divert or redirect traffic, and demand management. The strategies can also be organized by the phase of the recovery effort in which they usually occur. The Puget Sound Recovery Plan included transportation mitigation strategies from how to increase capacity on existing lanes to demand management and identified which of the individual strategies could be applied during short-, mid- or long-term phases of recovery. When determining potential mitigation strategies,

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Table 6. Temporary structure/detour pre-event tasks and considerations.

Pre-Event Tasks	Considerations
Determine temporary structure versus existing detour route criteria.	Coordinate with Continuity of Operations (COOP) process.
Select alternate or detour routes in advance.	Include impact on other modes of transportation.
Develop short-term infrastructure options and include multimodal solutions.	Consider developing multiple options, such as using undamaged portions of infrastructure. Incorporate integrated multimodal options—highway, transit, maritime, rail, and aviation—where possible.
Maintain list of utilities and updated contact information.	Coordinate with utility purveyors for utilities in rights-of-way.
Establish process for acquisition of temporary structures.	Consider maintaining an inventory of temporary bridges and pre-fabricated buildings.
Identify options for standardizing components and using pre-fabricated elements.	For example, evaluate suitability and availability of existing state and national pre-fabricated bridge standards.
Identify suppliers for pre-fabricated structures.	For example, pre-fabricated bridges and temporary structures such as pre-fabricated buildings.
Identify locations to stockpile and pre-position supplies and resources.	Consider stockpiling of components. Evaluate regional stockpiles and locations outside vulnerable areas.
Compile databases with critical recovery information such as location of fuel resources.	
Get conditional waivers in advance for short-term use of certain assets that may carry weight, size, or material restrictions, if required.	Understand weight limits and requirements for transport of equipment and supplies.

it is recommended to also establish a traffic prioritization scheme that determines which type of traffic has priority over another type for a certain location or time period.

After the 9/11 attacks severely damaged PATH and Metropolitan Transportation Authority (MTA) transit services, transportation operators in New York City developed transportation alternatives for traveling to lower Manhattan. Additional ferry services were quickly established to get New Jersey residents to New York City and back.

Pre-Positioning Supplies

As Hurricane Katrina was approaching the Gulf Coast, trainloads of rail repair supplies such as ballast, ties, and emergency equipment were staged outside the immediate storm area, and camp cars were put in place to support maintenance crews. These pre-positioning activities allowed the Class 1 railroads to reopen most of their lines in the New Orleans area within days of Katrina's landfall. As a result, the freight rail systems were able to play an integral role in post-Katrina recovery efforts by transporting heavy equipment, supplies, and relief equipment into the greater New Orleans region and along the Gulf Coast.

Maintaining a Supply of Temporary Structures and Developing a Policy for Their Use

After a fire damaged the I-87 New York Thruway Bridge, the bridge was removed and two temporary pre-fabricated bridges were installed on a portion of the original site to carry

the traffic flow while the bridge was reconstructed. Some states maintain an inventory of temporary structures and supplies for short-term recovery. For example, temporary bridge material is kept in locations around the state of Vermont for emergency use. In addition, a policy has been developed that addresses the requirements for emergency use and establishes limits on the duration of use to ensure that the temporary bridges do not become long-term solutions that then limit their availability for future emergencies. A copy of the Vermont DOT "Temporary Bridge Request Form" for temporary bridge facilities is provided in Appendix A.

Demolition: Partial or Complete

- Can a partially damaged structure be demolished without doing further damage to the rest of the structure?
- Is specialized demolition required, such as underwater demolition?
- What equipment would be required for demolition, such as concrete shears or other cutting devices?
- Will worker safety concerns at the site limit conventional methods, e.g., working adjacent to power lines or over water?
- How should debris removal, hazardous materials, and decontamination be handled?

A key to rapid recovery is how quickly the demolition and restoration can begin after the event. When a gasoline tanker accidentally crashed on the MacArthur Maze in Oakland, California, a firm that had just finished reconstruction work on the San Francisco Bay Bridge approach was able to redirect workers and equipment almost immediately to begin clearing debris. During the response to the London 7/7 transit bombings, access arrangements and permissions were granted for crews to begin planning and to determine specific equipment needs such as large cranes.

Along with access, there are other challenges typically involved in the demolition of infrastructure such as how to demolish a partially damaged structure without causing further damage to the remaining structure? Or how to conduct the demolition? Should it be conducted underwater or in environmentally sensitive areas? During the recovery of the I-40 Webbers Falls Bridge in Oklahoma, which had been struck by barges that partially collapsed the structure, construction crews faced both of these challenges. One span, which had fallen into the river, had to be removed through underwater demolition. Another partially damaged span rested on the barges that struck the bridge at one end, with the other end still attached to the undamaged portion of the bridge. To prevent further damage to the structure, the barges had to be stabilized and constantly monitored for movement during demolition. Table 7 provides an overview of pre-event actions and considerations that can assist in demolition decisions for critical assets.

Damage assessment includes both determining the extent of infrastructure damage and assessing the viability of continued use of the site. Research has found that early assessment decisions set the tone for the efficiency of the recovery. Although damage assessments can only be conducted after an event, systems and teams to support the recovery process can be created in advance. Removal of debris from initial clearing and demolition can be addressed and planned in advance. Planning to accommodate oversize and overweight vehicles to minimize subsequent damage to infrastructure is often overlooked. Much of the roadway infrastructure rebuilding that was necessary following the World Trade Center attacks was due to damage from heavy vehicles carrying debris from the site. Appendix C provides more detailed information on damage assessment.

An incident involving CBR agents will result in significant disruption of services. Compared to more common natural disasters, CBR incidents involve unique challenges and require significant

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Table 7. Demolition pre-event tasks and considerations.

Pre-Event Tasks	Considerations
Identify equipment required and contractor resources in advance. Maintain fresh list of potential specialized equipment suppliers.	Learn from previous experiences, including non-catastrophic incidents.
Identify supplementary support resources.	Major incidents may adversely impact the availability of equipment and resources.
Establish MOUs and put pre-approved contracts in place, if possible.	
Establish emergency contracting protocols in advance.	
Identify locations for positioning of supplies and heavy equipment.	Consider requirements for oversize equipment.
Identify right-of-way (air space/land) for staging areas.	
Get conditional waivers in advance for short-term use of certain assets that may carry weight, size, or material restrictions, if required.	Understand permit requirements. Account for existing equipment and material restrictions.
Identify who has overall responsibility for managing debris removal.	Develop debris removal strategies that minimize impact on transportation system.
Identify potential staging and debris storage areas. Develop a long-term plan for debris removal.	Consider impact of oversize and overweight vehicles on roadways.
Initiate discussions with waste-disposal facilities and landfills.	Clarify responsibilities involved in the clean-up operation, including how removal will be coordinated.
Discuss waste-disposal issues with the state solid-waste-management authority.	Include municipal waste landfills; construction and demolition debris landfills; hazardous waste landfills; and hazardous, municipal, and medical waste incinerators, if available.
Create waiver procedures and any mutual aid agreements required.	

operational adjustments. Pre-event planning was found to be essential. Having a restoration plan vetted in advance and facility personnel trained beforehand substantially reduces the overall time for restoration and recovery. Appendix D provides more detailed information on decontamination of hazardous materials.

Discussed below are two approaches to demolition and debris removal—coordinating with the incident response team in advance of the recovery effort and standardizing damage assessment.

Coordinate with Response Team in Advance of the Recovery Effort

After the London 7/11 transit bombings, recovery activity was coordinated in the background during the response to the incident. The London Underground Recovery Team was given space to begin planning for structural surveys and determining specific equipment needs, such as large cranes, for the recovery. It was clear from structural damage on the Edgeware Road train that a crane would be necessary to remove the train from the scene and that the structure where the crane would be placed required reinforcement to support the weight of the crane. Access arrangements and permissions were granted for crews to begin pouring the cement needed to reinforce the above-ground supporting structure where the crane would be placed.

Standardize Damage Assessment

Understanding the extent of damage is critical to assessing demolition needs. Becoming familiar with the assessment process and the people and organizations responsible for it before an event can help expedite the recovery process. Multiple organizations—from state and local DOTs to federal regulatory agencies—are likely to be involved in damage assessment, and each may have their own methodology and timeframe requirements.

In some states, such as Wisconsin, the DOT serves as the coordinating agency for the assessment of infrastructure damages in the state. Iowa DOT functions as the coordinator for the FHWA ER program and processes the DDIRs. The DDIRs are used to document cost estimates for emergency repairs and also to determine eligibility, scope, and cost estimate for work. The FHWA uses the DDIR to support its request for emergency repair funding.

After the flooding in the Midwest in June 2008 (see Appendix B for Midwest Flooding case study), all of the projects that were submitted to FHWA from the Iowa DOT, Iowa counties and cities, the Iowa DNR, and railroad crossing systems within the state of Iowa were required to be submitted in the form of a DDIR.

Caltrans has established a Safety Assessment Program (SAP) to quickly produce damage assessments after an event. This Emergency Management Program for registered professionals such as licensed engineers, architects, and building inspectors provides training for rapid damage assessments. Caltrans has also implemented a land-based, laser scanning technology as a result of research from the Advanced Highway Maintenance and Construction Technology (AHMCT) research center at the University of California at Davis. This technology measures and models bridges, structures, roadways, slide areas, accidents, and archeological sites. The technology was used to accelerate the reconstruction of the MacArthur Maze collapse in May 2007. Photogrammetry and laser scanners documented the site prior to debris removal and provided the dimensions for prefabrication at remote locations.

Design: Identical or New Design

- Build "as is" or design new structure?
- Can designs be simplified, such as reducing architectural details in temporary structures?
- Should desired or planned infrastructure improvements be incorporated into the designs?
- Are design drawings available?

Making design decisions as soon as possible can minimize recovery time. Some design decisions can be made before an event, such as what design strategies to take when rebuilding or replacing existing infrastructure. For example, using existing plans and footprints where possible—"as is" design—or using simplified designs can expedite recovery. Design preparations can also be made before an event for making infrastructure improvements where possible. Planned bench walls, lighting, and communication enhancements were added during recovery construction of the PATH tunnels after 9/11. Table 8 provides an overview of pre-event actions and considerations that can assist in design decisions for critical assets. Discussion follows of using simplified designs to expedite reconstruction, using existing plans and footprints where possible, and maintaining and providing access to designs, plans, and other key data.

Using Simplified Designs to Expedite Reconstruction

After 9/11, the New York/New Jersey Port Authority use of simplified design allowed for ordering longer lead-time materials for the World Trade Center stations before the contractor was

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Table 8. Design pre-event tasks and considerations.

Pre-Event Tasks	Considerations
Determine design approaches in advance, e.g., "as-built" design or new design.	Early decisions as to using the "as-built" design or a new design determine the minimum recovery time achievable.
Identify simplified design opportunities.	Consider reducing or eliminating architectural details or leaving conduits exposed, especially in designing temporary structures, to expedite recovery.
Create flexible "templates" of options to consider. Include potential enhancements and infrastructure improvements.	Use planning process to discover innovative design solutions.
Apply "build back better" principles, even if they have not been translated into specific codes or standards.	Update plans and procedures based on experiences identified in After-Action Reports. Revaluate design standards with consideration of climate effects and incorporating updated National Oceanic and Atmospheric Administration (NOAA) precipitation frequency estimates.
Gather and maintain design drawings and specifications.	Less time is required to design a recovered structure when original design drawings and specifications are immediately accessible.
Document configuration changes arising from construction, repairs, inspections, and alterations.	Establish back-up document storage at alternate locations.

hired. The lack of architectural detail in the temporary PATH stations allowed bidding on the necessary steel on a per-pound basis before the design was even finished. The conduit carrying the utilities and cabling was left exposed, eliminating the design time needed to artfully bury it. These strategies shaved 1 year off the construction schedule.

Using Existing Plans and Footprints Where Possible

To restore train service to the World Trade Center site as quickly as possible, a temporary PATH terminal was built at the location of the destroyed facility, enabling engineers to utilize previous alignments and reduce additional excavation/foundation work.

Maintaining and Providing Access to Designs, Plans, and Other Key Data

The case studies suggest that less time was required to design structures when original design drawings and specifications were immediately accessible to designers and contractors. For example, CC Meyers used existing bridge plans to procure steel and other needed materials prior to the contract for MacArthur Maze/Bridge repair and reconstruction.

The current as-built drawings, information pertaining to the rights-of-way, and any special considerations that might impact recovery activities should be maintained and readily accessible. Configuration changes arising out of construction, repairs, inspections, and alterations to the infrastructure should be documented. Prior to the Howard Street Rail Tunnel Fire in Baltimore, Maryland, information about modifications and construction in or near the tunnel had not been reliably documented or exchanged by city officials, responders, and private industry. For example, information indicated that a storm sewer was 19 feet below the surface near a test drilling. However, during the drilling project, the drill struck the storm sewer, which was only about 8 feet below the surface.

Many of Iowa's roadway and bridge design plans, shop drawings, and other infrastructure record documents are available electronically on a 24-hour basis in the Iowa DOT's ERMS. Since the ERMS system was installed, Iowa DOT has seen a 430% return on investment (ROI) from cost savings associated with electronic records management. The previous paper-based process required 45,000 square feet of storage for paper documents and 25% more employee time than the hardware-based repository.

Contracting Options and Processes

- How to select a contractor?
- What type of contract should be used?
- How can the contracting and approval process be expedited?

Major repair or replacement construction requires contracting for engineering and contractor services. Putting in place contracts and procedures before an event can speed up the contracting negotiation process and avoid contract disputes during/after recovery. Some options for contracting in advance are provided in Figure 10.

Most state transportation agencies have the ability to procure goods and services through emergency contracts once certain declarations of emergency are made. Standard competitive bidding processes can often be waived, and qualified contractors can be requested to bid on the repair work. Understanding the processes for enabling emergency contracting provisions before an event occurs can help expedite the recovery process. Table 9 provides an overview of pre-event actions and considerations that can assist in contracting processes for infrastructure. Further discussion follows on pre-qualifying vendors and contractors, expediting contracting approaches and approvals, and innovative contracting approaches.

Pre-Qualifying Vendors and Contractors

Having a pre-qualified list of engineers and contractors to contact will expedite the recovery process. Because it has been recognized that the use of "quality of work" as a category in pre-qualification of contractors can be vague and subjective, AASHTO has developed guidance on

Contract Option	Comments
Pre-Event Contracts	If normal federal-aid requirements are met, including competitive low-bid advertisements, pre-event contracts are allowable. FHWA has approved boilerplate language for Construction Engineering and Assessment (CEI) services, debris monitoring, cut and toss and debris removal, traffic control signals, permanent lighting, and signal repair. Pre-event contracts for other work types may be acceptable as long as FHWA federal-aid requirements are met. For pre-event contracts that identify a sole source material supplier or proprietary product, a Public Interest Finding must be sent to FHWA for approval in advance of executing the contract, as per 23 CFR 635.411.
Pre-Existing Contracts	Existing contracts may be used to provide for emergency services and the purchase of commodities if the emergency service or commodity required falls within the original intent of the contract, or if the scope of services/specification addresses providing for emergency situations.
Stand-by Contracts	Stand-by contracts can be put in place for critical recovery equipment and supplies to help ensure that recovery supplies are available in the quantities needed and at a reasonable price. Typically, these contracts establish prices as those in effect on the day before the event occurred.

Figure 10. Advance (pre-event) contract options.

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Table 9. Contracting pre-event tasks and considerations.

Pre-Event Tasks	Considerations
Develop list of pre-qualified engineers and contractors. **Maintain fresh list of potential contractors for competitive bidding.**	Select contractors with resources and expertise to accomplish projects under emergency situations.
Establish contract templates and contracting protocols. **Put in place contracts, mutual aid and assistance agreements, and MOUs, if possible.**	Establish programmatic agreement, memorandum of agreement (MOA), or informal agreements to document rules of engagement, roles, and responsibilities.
Identify supplementary support resources. **Put in place mutual aid agreements to pool community and regional resources, if possible.** **Develop contingency plans, especially for situations when mutual aid and resource sharing is not possible.**	Major incidents may adversely impact the availability of engineering, contractors, and materials. Consider formal regional resource-sharing compacts. Emergencies that affect large regions can make resource sharing within the region impossible.
Establish emergency contracting protocols in advance. **Develop/practice accelerated administrative process.**	Flexibility in operational and contracting procedures can expedite reconstruction process.
Identify and designate contracting officers. **Establish relationships in advance among project stakeholders.**	Experienced contracting officers are critical in situations where problems may be encountered or when federal reimbursements are sought.

generally accepted information categories to use for pre-qualification (AASHTO 2006, FHWA 2006). These categories include detailed financial statements, resident agent, capacity and control classification, experience and performance, ownership or control, and equipment. It should be noted that pre-qualification of contractors, although helpful, is not sufficient to ensure that the necessary expertise, equipment, and materials will be available when needed most. Ohio, Massachusetts, and Vermont require that contractors be on a list of pre-qualified vendors to be awarded an emergency contract.

Expediting Contracting Approaches and Approvals

During times of emergency, an accelerated contracting and approval process can reduce the time required for infrastructure repairs and construction. Establishing the protocols in advance and practicing their implementation is key to accelerating the process.

States have their own laws, regulations, and procedures for emergency contracting for DOTs. Some states have statutes and regulations similar to those of the federal government; others follow a model code published by the American Bar Association (ABA). Provisions in the ABA's model code authorize contracting officers to use emergency, non-competitive procedures when there is a threat to public health, welfare, or safety.

Selected Studies in Transportation Law—Volume 1: Construction Contract Law reports the results of surveys to better understand and document practices at state DOTs (Boland and Cade 2004). This research found that states that suffer natural disasters or emergencies more frequently are generally more prepared and have detailed and complex regulations and guidelines that they follow. For example, Florida and Alaska have detailed written procedures, guidance, and checklists for emergency contracting and pre-printed forms for a natural disaster emergency contract.

Some states have guidance provided in their procurement manuals defining an emergency situation. For example, the Wisconsin Procurement Manual calls for immediate action when a situation exists that is a threat to public health, safety, and welfare; the manual allows for action following an unforeseen event. Similarly, the Arizona Procurement Code provides that emergency procurements will only be used when a situation exists that is not only a threat, but that also makes compliance impracticable, unnecessary, or contrary to the public interest.

The Louisiana Department of Transportation and Development (LADOTD) typically uses a two-phase contractor selection process. Due to the emergency nature of the I-10 Twin Span project after Hurricane Katrina, the LADOTD conducted procurement using a single-step process that did not include a short-listing phase. In each case, the rules for contact with the agency are clearly defined in the Request for Qualifications (RFQ) and Scope of Services Package (SOSP) documents in order to promote a fair, unbiased, and legally defensible procurement process.

Innovative Contracting Approaches

The innovative contracting methods that expedited completion of multiple projects after the 1994 Northridge Earthquake in California—A+B bidding (a combination of cost and time), invitational bidding, and design-build bidding—are cited as a best practice in the U.S. DOT's *Recovering from Disasters: The National Transportation Recovery Strategy* (2009). LADOTD utilized design-build in order to "fast track" the $40 million emergency repair of the I-10 Twin Span Bridge over Lake Pontchartrain between New Orleans and Slidell. The Twin Spans were severely damaged by Hurricane Katrina, and the primary reason for using design-build was to accelerate the project schedule so as to reopen I-10 to traffic as quickly as possible.

NCHRP Synthesis 379: Selection and Evaluation of Alternative Contracting Methods to Accelerate Project Completion (Anderson and Damnjanovic 2008) provides an overview of the process for selecting alternative contracting methods that can potentially accelerate project completion.

MnDOT has produced a web-based resource, *Innovative Contracting Practices,* which provides detailed information on new practices to supplement traditional low-bid, Design-Bid-Build contracting that can decrease project delivery time and reduce construction time.

The Florida DOT's design-build project selection guidelines provide a list of the types of projects that are suitable for design-build and examples of projects that may not be good candidates for design-build. According to the observations summarized in *Current Design-Build Practices for Transportation Projects* (Transportation Design-Build Users Group 2009), one of the most important factors for the success of a design-build project is the ability of the contracting agency to adequately define the scope of work in the request for proposals (RFP) document. A series of pre-scoping questions have been developed by the Florida DOT to assist in defining the design-build project scope available in Appendix A.

Construction Strategy and Techniques

- What construction strategies are available for recovery? What construction strategies can be used to accelerate construction?
- What construction techniques are available to expedite recovery?
- What can be done in advance to prepare for recovery construction?

A number of construction strategies can expedite recovery by minimizing disruption and reducing project delivery time. Such strategies include using the design-build process, planning for staged or phased construction, and utilizing accelerated work schedules. MnDOT accelerated the delivery of the I-35W Mississippi River replacement bridge project using the design-build

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process. This procedure allows overlapping design and construction, enabling construction to start before all designs are approved and final.

After 9/11, a phased construction approach was used to restore PATH service to lower Manhattan. A series of temporary transit stations and entrances were used to provide service while the permanent station was under construction.

When the I-87 New York Thruway Bridge was damaged in a fire, a staged construction approach was used to replace the damaged bridge. Temporary pre-fabricated bridges were installed on part of the original site while the bridge was reconstructed. When a portion of the damaged bridge was reconstructed, traffic was rerouted onto it, and one of the temporary bridges was removed. When the second portion of the reconstructed bridge was ready for traffic, traffic was rerouted onto it, and the last temporary bridge was removed. The staged construction minimized the disruption to traffic flow and to the surrounding communities. Table 10 provides an overview of pre-event actions and considerations that can assist in construction for infrastructure projects. Further discussion of using pre-fabricated or modular elements, innovative use of equipment or materials, and accelerated work schedules follows.

Using Pre-Fabricated or Modular Elements

In the case studies of bridge replacement projects, it was found that using pre-fabricated or modular elements prevents weather impact on production and delivery, shortening the reconstruction process. Pre-fabricated elements have been used to accelerate construction in tunnels; some of these pre-fabricated elements include steel and pre-cast concrete sunken tubes, pre-finished steel ceiling panels, and pre-cast concrete plenum wall dividers. Identifying potential applications for pre-fabricated elements can be done prior to an event.

Innovative Use of Equipment or Materials

Innovative use of construction equipment and materials can reduce construction time significantly. A 2005 article on Tradeline, Inc. (Wesel 2005) reported on the use of "road headers," excavating equipment outfitted with a massive rotating grinding ball at the end of a long arm, in the recovery after 9/11. Construction of a new 1,500-foot crossover tunnel required boring

Table 10. Construction pre-event tasks and considerations.

Pre-Event Actions	Considerations
Develop list of pre-qualified engineers and contractors.	Maintain fresh list of potential contractors for competitive bidding.
Identify supplementary support resources.	Major incidents may adversely impact the availability of engineering and contracting.
Identify effective practices for expediting repair and reconstruction.	Consider use of pre-fabricated or modular materials, e.g., use of pre-stressed concrete girders in lieu of the original steel girders.
Document observations derived from small disturbances and prior events.	Use prior experience to plan for quickly repairing damaged infrastructure.
Develop approaches for accelerated construction techniques.	Consider phased construction arrangements and design-build, if available.
Explore innovative uses of construction equipment and materials.	Identify previous practices and experiences from other states and regions.
Establish relationships in advance among project stakeholders.	Establish relationships in advance to develop cooperative attitude among project stakeholders.

through bedrock and removing 10,000 cubic yards of rock 100 feet below street level. The original plan was to blast and drill through the bedrock, but the Port Authority thought that the work was moving too slowly so turned to road headers to get the job done more quickly. Jim Palmer, lead technical advisor on the restoration of PATH service between New York and New Jersey, is quoted in the Tradeline article as remarking, "We burned a lot of time getting the road headers up and running. . . . That was a real lesson we learned. Next time, I'd have my options laid out in advance."

According to the Tradeline article (Wesel 2005), the sequence of construction inside the PATH tunnels was done differently as well, following a process developed in conjunction with the contractor, who wanted to use rubber-tired equipment to bring in materials. Instead of laying track first, the typical approach, the contractor's desired approach required locating everything first and then laying the track last. To accommodate this process, a high level of survey control was developed along with a "clearance jig" to make sure trains would have enough clearance.

Accelerated Work Schedules

Accelerated work schedules can be used to complete recovery projects in shorter periods of time. This approach was used in the reconstruction of the I-40 (Oklahoma) and I-35 bridges. According to research studies, accelerated construction at a reasonable cost and with a safe project site environment requires coordination and cooperation among all project participants. Planning in advance can help establish the relationships and communication necessary to achieve the required levels of coordination and cooperation.

Project Management and Delivery Approaches

- What types of project management are available?
- Which type of project management approach should be used?
- What can be done before an event to prepare for project management selection?

Project management and delivery describes the relationships and contractual obligations among the owner, designer, and contractor for a construction project. The project delivery process may include planning, budgeting, environmental analysis, design, and construction. There are a number of project management/delivery approaches, and they can be grouped into three types: Design-Bid-Build, Design-Build, and Construction Manager/General Contractor or Construction Manager-at-Risk. Design-Bid-Build is the traditional project management arrangement. Construction Manager-at-Risk and Design-Build are accelerated project management approaches.

State laws may restrict the use of alternative project delivery methods such as Construction Manager-at-Risk and Design-Build. In a 2008/2009 survey of state DOTs reported in *NCHRP Synthesis 402: Construction Manager-at-Risk Project Delivery for Highway Programs* (Gransberg and Shane 2010), of the 47 states that responded, 26% were allowed to use Construction Manager-at-Risk and 62% were allowed to use Design-Build for DOT projects. (All states that responded to the survey were allowed to use Design-Bid-Build within the DOT.)

Federal project oversight is often needed in large emergency projects, especially when the resources of the state become over tasked. After 9/11, the FTA created the LMRO to work on innovative, streamlined project delivery processes for recovery of transportation services and consensus among federal and local partners. Table 11 provides an overview of pre-event actions and considerations that can assist in project management and delivery of infrastructure projects. Discussed below are two effective practices for project management and delivery—development of a project delivery acceleration toolbox and streamlining project delivery processes.

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Table 11. Project management/delivery pre-event tasks and considerations.

Pre-Event Actions	Considerations
Evaluate the state regulatory framework for accelerated project delivery.	State laws may restrict the use of alternative project delivery methods.
Identify what approvals (federal and state) are required for each approach, e.g., SEP-14.	Maintain regular and open channels of communication with regulatory agencies.
Identify effective practices for guidelines and contracting, e.g., project scoping and risk allocation.	
Identify or develop, if necessary, documented procedures for selecting a project delivery method based on project characteristics.	
Identify or develop, if necessary, policy for selecting a contractor based on project characteristics.	
Establish contract templates and contracting protocols.	Establish programmatic agreement, MOA, or informal agreement to document rules of engagement, roles, and responsibilities.
Develop and practice accelerated administrative process.	Workers and managers need to communicate across communication barriers so that information is passed horizontally and quickly.
Establish relationships in advance among project stakeholders.	Smooth project completion requires exceptional coordination among the stakeholders in the project.

Project Delivery Acceleration Toolbox

Caltrans has developed an online project delivery acceleration toolbox (available at http://www.dot.ca.gov/hq/oppd/projaccel/index.htm) that lists department efforts (past and present) to accelerate the delivery of transportation projects and provides the department's employees, as well as external partners, with tools to accelerate project delivery.

Streamlined Project Delivery Processes

The LMRO in New York City developed innovative, streamlined project delivery processes that included using one grant for the entire project, developing a master agreement for both FTA and FEMA requirements, creating an MOU among federal agencies for environmental oversight, and creating a Federal Interagency Review Team.

Environmental Requirements

Regulations, policies, and procedures are the driving forces behind the compliance approach used during and after events. As outlined in *Implementing the National Environmental Policy Act (NEPA) for Disaster Response, Recovery, and Mitigation Projects* (Luther 2011), several classes of disaster response and recovery projects funded by FEMA are statutorily excluded from NEPA under the Stafford Act. In these cases, there are no NEPA requirements to be met before implementing the project; however, all other environmental and historic preservation laws and Executive Orders still apply. The types of projects that are typically excluded from NEPA are temporary emergency repairs of facilities, debris removal, and restoring facilities to pre-disaster condition (including pre-disaster function, capacity, and footprint). For all other types of projects, including retrofitting or improving facilities to mitigate risk to hazards, NEPA is required. An environmental assessment (EA) or environmental impact statement (EIS) must be prepared

for projects that don't qualify for a categorical exclusion (CE)—defined per 40 CFR 1508.4 as a "category of actions which do not individually or cumulatively have a significant effect on the human environment . . . and . . . for which, therefore, neither an environmental assessment nor an environmental impact statement is required."

For roads and facilities subject to FHWA oversight, several CEs and programmatic categorical exclusions (PCEs) to NEPA apply to repair and reconstruction actions that may be encountered after an event. In these situations, assessing and documenting effects on the environment and other regulated resources are still required; however, little or no public involvement is required as mandated by NEPA. Coordination with other state agencies may also be required to satisfy any state environmental policy act or other laws.

For roads and facilities not subject to FHWA oversight, compliance with NEPA is still required if any federal funding or permitting is required for the project. In these cases, the compliance process must be aligned with the regulations, policies, and procedures of the lead federal agency (e.g., FEMA or the USACE).

Pre-event planning such as organizing environmental and historic preservation database files of resource locations in conjunction with transportation assets will also facilitate expeditious identification of sensitive resources. Resource locations can be obtained from a variety of sources including documentation on file from the original permitting of the road or facility and online resources maintained by state or federal regulatory agencies. Resource location maps can be overlain on transportation maps and maps indicating facilities with repetitive loss histories and integrated into emergency management software. Involving federal and state regulatory agencies and stakeholders during the pre-event planning process can focus the data collection and management on the most important resources that are present at any given site. Table 12 provides an overview of pre-event actions and considerations that can assist in complying with environmental requirements

Table 12. Environmental pre-event tasks.

Pre-Event Tasks	Considerations
Evaluate the regulatory framework currently in place. **Develop scope for the project and gather baseline resource identification studies for lead agency review.** **Build compliance requirements into the operations of the transportation management agency.** **Identify an individual or departmental unit in the lead role for environmental and historic preservation compliance.** **Identify counterparts in the regulatory agencies and establish standardized communication channels.**	Coordination with state DOTs and FHWA districts should occur to determine which CEs are in effect and could apply to a variety of events. Coordination with other state agencies may also be required to satisfy any state environmental policy act or other laws. Consider centralizing internal review process. Define the roles and responsibilities of obtaining permits and overall compliance. Provide a single point of contact for the incident command team and regulatory agencies role for environmental and historic preservation compliance.
Maintain regular and open channels of communication between the transportation management agency and the resource regulatory agencies. **Develop an informal agreement for the procedures and protocols or formalize a binding programmatic agreement or MOA, if possible.**	
Organize environmental and historic preservation database files of resource locations in advance.	Involving federal and state regulatory agencies and stakeholders during the pre-event planning process can focus the data collection and management on the most important resources that are present at any given site.

for infrastructure projects. Discussed below are the following effective practices: limiting the project scope to reduce complexity, maintaining good working relationships and open lines of communication, and having access to good data.

Limiting the Project Scope to Reduce Complexity

After the I-35 Bridge collapsed in Minneapolis, Minnesota, on August 7, 2007, MnDOT decided that the new bridge would have the same capacity and alignment as the old bridge. This limited scope eliminated the expanded environmental review and possible controversies, a common occurrence with large construction projects.

A section of the I-10 Bridge crossing Escambia Bay in Florida collapsed during Hurricane Ivan on September 16, 2004. Although the alignment of the new bridge was shifted slightly to accommodate height and width changes, it still lies mainly within the footprint of the previous bridge. Maintaining the original footprint significantly reduced the environmental impacts of the rebuilding project.

Maintaining Good Working Relationships and Open Lines of Communication

Historically, there had been a strained working relationship between the Florida Department of Environmental Protection (FDEP) and the Florida DOT. To encourage a better relationship and to build trust, quarterly meetings were established between the two agencies. In the aftermath of Hurricane Ivan and the destruction of the I-10 Bridge, the pre-existing interagency relationships facilitated communication between FDEP and FDOT and allowed the state-level environmental permits to be quickly processed.

Having Access to Good Data

The Oklahoma DOT, the SHPO, and the Oklahoma State Archeologist had taken inventories of natural, cultural, and historic resources through ODOT's Cultural Resources Program in the Arkansas River area, which helps identify potential cultural and historic sites that may require special attention as part of highway projects. When the I-40 Bridge accident occurred, these agencies were able to immediately identify potential natural and historic issues, eliminating the need for additional investigation and studies to identify and understand any potential environmental problems for the reconstruction project.

CHAPTER 6

Recovery Funding

It is important to be aware of recovery funding resources in advance of an emergency and to understand the eligibility and documentation requirements for obtaining that funding. This chapter provides an overview of the funding potentially available for rebuilding and recovery. Table 13 provides an overview of federal, state, and other potential funding sources that may be available for the recovery of transportation assets. See Appendix E for more detailed information on recovery funding sources.

States typically have a Disaster Emergency Fund that can be used to finance recovery efforts and to match grant dollars provided by the federal government. It should be noted that the availability and extent of funding varies by state. In most cases, if this funding is not enough, or the state requires additional recovery funding that cannot be acquired from other sources, the governor (or another similar state government official) has the authority to allocate additional state funding for recovery assistance. Two examples of effective practices in state transportation recovery funding follow.

Wisconsin has established a Flood Damage Aid Program for the state DOT that covers the restoration of roadways (not including state highway roads) damaged by flooding, as well as mitigation repairs. The state program requires local match funding.

California has established a number of state transportation funding options to expedite recovery projects including the following:

- The Disaster Assistance Fund, a special fund within the state treasury that is available for use by agencies during the recovery process. A subsidiary account, called the Earthquake Emergency Investigations Account, covers expenses incurred by earthquake damage.
- The California Transportation Commission's Resolution G-11 allows the DOT to allocate its funds as necessary to repair emergency damages. To allow the department to begin the recovery process as soon as possible, the resolution becomes active "whenever an event places people or property in jeopardy, causes or threatens to cause closure of transportation access, or causes either an excessive increase in delay or congestion, or an excessive increase in the necessary distances traveled."
- State Highway Operation and Protection Program (SHOPP) funding can be used to repair transportation systems. SHOPP funding is divided between proposed projects and reservation funding. Emergency and disaster funds are available from the reservation funding.

Table 13. Overview of recovery funding sources.

Funding Authority	Funding Program	Description
Stafford Act Programs	**FEMA Public Assistance (PA)**	PA grants are FEMA's primary assistance program for state and local governments. These grants may be used to repair, replace, or restore disaster-damaged, publicly owned facilities and the facilities of certain private nonprofit organizations.
	FEMA Hazard Mitigation Grant Program (HMGP)	FEMA's HMGP provides grants to states to implement mitigation measures during recovery from a disaster and to provide funding for previously identified mitigation measures.
Other Federal Programs	**U.S. Department of Housing and Urban Development Community Development Block Grants (CDBGs)**	CDBG funds are generally allocated to states for housing and community development purposes. In recent years, this program has been a vehicle for delivering additional disaster aid to states with major disasters.
	Economic Development Administration (EDA) Grants	EDA grants are available to regions experiencing sudden and severe economic dislocations such as those resulting from natural disasters. Funds can be used for infrastructure to support community economic development.
	Special Funding	Congress can enact special legislation to provide emergency funding. For instance, P.L.109–87 authorized the Secretary of Transportation to make project grants for airports that incurred emergency capital costs because of Hurricanes Katrina or Rita.
U.S. DOT Grants	**FHWA Emergency Relief (ER) Funds**	ER is a special program from the Highway Trust Fund. Funds are available for the repair of federal-aid highways or roads on federal lands that have been seriously damaged by natural disasters over a wide area or by catastrophic failures from an external cause.
	Emergency Relief for Federally Owned Roads (ERFO)	ERFO provides funding and engineering services for the repair and reconstruction of roads in public lands after a natural disaster or a catastrophic failure. The following categories of roads are eligible: Forest Highways, Forest Development Roads, Park Roads and Parkways, Indian Reservation Roads, Public Lands Highways, Refuge Roads, Military Installation Roads, Corps Recreation Roads, Bureau of Reclamation Roads, and Bureau of Land Management Roads.
State Programs	**State Disaster Emergency Funds**	States typically have a Disaster Emergency Fund, regularly appropriated by the state government, which can be used to finance recovery efforts and to match grant dollars provided by the federal government. The amount of funds varies by state; states that are more vulnerable to disasters may place greater amounts of money in their Disaster Emergency Fund than states that have not typically been victim to many disasters. In most cases, if this funding is not enough, or the state requires additional recovery funding that cannot be acquired from other sources, the governor (or another similar state government official) has the authority to allocate additional state funding for recovery assistance.
	State Bond Initiatives	State and local bond issues are major vehicles through which state and local governments can finance public projects, especially project upgrades that are not eligible for FEMA's PA grant program. These bonds do not require a presidential disaster declaration. These public purpose bonds are used for roads, streets, highways, sidewalks, libraries, and government buildings. Bond funding can be used by state and local entities to pay the match portion of PA projects, as well as pay for upgrades.
Other	**Private Insurance**	The NTRS recommends that insurance coverage be evaluated prior to an event to ensure sufficiency and to understand the limitations of liability insurance policies in situations where people may need to be evacuated or temporarily displaced from their homes due to a transportation disruption.

CHAPTER 7

Communications and Collaboration

Emergency recovery situations generally bring together people who may not work together in non-emergency situations. Establishing relationships and communication between people who will likely work together in emergency recovery situations in advance of an event can be useful in developing effective recovery procedures and communications processes. The establishment and ongoing fostering of such relationships can assist in meeting the information needs of each phase of the recovery (short term, mid-term, and long term) and thereby help in meeting the goals of each recovery phase. Figure 11 provides an overview of typical goals and needs for each phase of the recovery process.

There are some common barriers to communications and collaboration including legal and structural restrictions, cultural differences, lack of leadership, and communication equipment issues. However, failure to develop effective processes for working across agencies prior to an event can lead to an ineffective and prolonged recovery. Table 14 provides an overview of pre-event actions and considerations that can assist in communications and collaboration. Three potential approaches to improving or establishing communications and collaboration are discussed below—building on existing ad hoc relationships, learning from regional coordination models, and involving the community to establish support.

Build on Existing Ad Hoc Relationships

An effective collaboration strategy is to build on existing ad hoc relationships among key agencies and jurisdictions to start the process. Agencies involved in emergency management and law enforcement, as well as fire departments and regional agencies that play significant roles in initial emergency response and recovery, should be considered.

Regional Coordination Models

Major events often have a regional impact. There are a number of existing models for regional coordination in transportation recovery:

- Local agencies taking the initiative to organize working groups to address regional issues. For example, Caltrans has established an interagency/intercounty working group to coordinate planning and address recovery and implementation issues such as what mitigation procedures can be used and where, e.g., hydromulching for erosion control after wildfires. Joint training exercises can be used to work through potential issues and plans before an event.

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Recovery Phase	Goals	Information Needs
Short-Term Recovery	Gain situational awareness Implement detours/alternate routes Utilize mutual aid for emergency repairs Share public information	Share information from field assessments, such as status of local routes, damages, and closures. Establish detours for damaged transportation infrastructure in collaboration with affected and adjacent jurisdictions. Request resources from mutual aid partners. Send out consistent public messages.
Mid-Term Recovery	Coordinate with regional partners Implement additional alternate routes and adjust traffic management Build public support	Prioritize interim needs. Design multimodal solutions that integrate roadway, transit, maritime, rail, and aviation resources. Implement demand-management strategies. Provide shared and consistent public messages.
Long-Term Recovery	Establish regional priorities Develop long-term plans Build public support	Evaluate disaster impact on transportation services and estimate timelines for repair and reconstruction. Seek public input and provide timely information. Demonstrate interagency collaboration.

Source: Adapted from Transportation Recovery Annex (2011).

Figure 11. Communications/collaboration goals and needs by recovery phase.

- Taking advantage of existing organizations such as metropolitan planning organizations (MPOs) and regional transportation planning organizations (RTPOs). It has been recommended by the FTA and planning advocacy organizations such as the Association for Metropolitan Planning Organizations and National Association of Regional Councils that MPOs/RTPOs take on a "convener" role or act as a forum where regional plans could be discussed and coordinated for recovery. In addition, the MPO/RTPO could conduct vulnerability analyses on regional transportation facilities and analyze the regional transportation network for emergency route planning and strategic gaps in the network and services.
- States establishing taskforces or working groups to address regional recovery as part of states' long-term recovery strategy. For example, Iowa includes a Transportation Appendix in its State Recovery Plan that includes the roles, responsibilities, and a framework for post-disaster transportation recovery.

Involve Community to Establish Support

Support from communities has proved to be a critical factor for successful expedited infrastructure replacement projects. The I-35 Bridge project team in Minnesota involved the community extensively in the design and construction of the replacement bridge. This collaboration, deliberately carried out to enlist maximum participation, was key to rebuilding the collapsed bridge ahead of schedule and under budget.

Table 14. Communications and collaboration pre-event tasks and considerations.

Pre-Event Actions	Considerations
Develop an extensive list of contacts. Know how to contact: • Local and state Emergency Operations Centers (EOCs); • Local, regional, or state Transportation Management Centers (TMCs); • Regional Councils of Government (COGs) or Metropolitan Planning Organizations (MPOs); • Regional Emergency Transportation Coordinating Officials (RETCOs) and the Regional Emergency Transportation Representative (RETREP).	Learn who controls and has decision-making authority for all transportation systems and infrastructure within the boundaries of interest and get to know lead decision-makers. Gather regular and emergency contact information along with role/responsibility.
Identify existing regional working groups and committees to address recovery issues.	Involve community representatives on committees and working groups.
Plan exercises and joint training sessions to help establish relationships and common understanding.	Include communications protocols and communications procedures in exercises and training.
Identify and provide communications equipment required for recovery operations. Collect communications equipment instructions.	Include multiple types of equipment such as hand-held satellite systems and hand-held radio systems operable as "point-to-point" as well as repeaters. Include replacement batteries for issued mobile radios. Provide mobile communications radios for assisting agency command personnel in the event that these personnel are not equipped with radios using the same frequency.
Compile radio frequency lists, including on-scene emergency frequency for local/regional agencies.	Include local, state, and national channels. Collect channel and frequency being used.
Develop internal and external communications procedures, including establishing message transmission protocols and procedures to establish mobile communication recovery centers.	Define clear and streamlined communications protocols among responders, engineers, contractors and all other impacted stakeholders including the media. Ensure that information can be passed quickly and, importantly, horizontally.
Plan exercises to practice implementing communications protocols and to identify gaps in communications procedures.	Update information lists and procedures based on experience with the exercises.
Identify the key stakeholders that will be involved in recovery efforts. Get contact information by agency and designated representative. **Developing regional, formal resource-sharing and coordination compacts when needed.**	Build on existing ad hoc relationships among key agencies and jurisdictions. Examples of the types of agencies to include are emergency management, law enforcement, and fire departments, along with regional agencies that play significant roles in initial response and recovery.
Develop relationships by holding joint trainings, planning sessions, and informal social events (such as off-site dinners).	Enlist champions and leaders who are committed to working together as part of a collaborative recovery team.
Identify approaches to encourage a cooperative attitude among recovery stakeholders.	Compile successful approaches in other states/regions.
Identify common information and data needs. **Identify and procure ready-to-use mapping, e.g., Geographical Information System (GIS) canned maps and flood inundation maps.** **Plan joint exercises to practice information sharing and cooperation.**	Facilitate sharing of required data and information.
Establish public communication processes and protocols.	Identify types and pre-positioning locations for signs and advisory equipment.
Develop an accessible public information campaign that addresses an array of possible scenarios.	Include public communication processes in joint exercises to assess effectiveness.

CHAPTER 8

Recovery Management

Clear recovery management policies and practices, with roles and responsibilities identified in advance, are essential to an effective recovery process. Table 15 provides an overview of key recovery management functions with corresponding pre-event actions.

Table 15. Recovery management pre-event actions.

Key Management Functions	Pre-Event Actions
Agency Notification and Mobilization	Create key recovery personnel contact lists. Get contact information by agency and designated representative. Build on existing ad hoc relationships among key agencies and jurisdictions. Examples of the types of agencies to include are emergency management, law enforcement, and fire departments, along with regional agencies that play significant roles in initial response and recovery. Develop internal communications procedures to ensure that information can be passed quickly and, importantly, horizontally. Encourage participation of all relevant agencies' senior and junior staff in joint training and planning sessions to foster relationship building, communication, trust, and appreciation for each other's roles. Get continued reinforcement from senior management through ongoing support for annual trainings/interactions, including dedicating resources to joint initiatives.
Mobilization of Recovery Facilities and Equipment	Identify critical recovery equipment and sources, if necessary. Put in place contracts and MOUs with equipment providers and supporting resources. Compile databases with critical recovery information such as location of fuel resources, location and strength of field personnel available.
Internal Direction and Control	Create emergency accelerated approval process. Establish the approval protocols in advance and practice their implementation. Identify recovery operations team roles and responsibilities; these should be separate from emergency response, given the demands of recovery. Identify person or department responsible for managing recovery process. Ensure recovery team is involved in emergency management planning processes. Identify and designate experienced contracting officers in situations where problems may be encountered or when federal reimbursements are sought.

Table 15. (Continued).

Key Management Functions	Pre-Event Actions
External Coordination	Get contact information by agency and designated representative. Build on existing ad hoc relationships among key agencies and jurisdictions. Examples of the types of agencies to include are emergency management, law enforcement, and fire departments, along with regional agencies that play significant roles in initial response and recovery. Develop pre-established Mutual Aid Agreements with other key agencies in same and adjoining areas to formalize/authorize assistance during emergency events. Identify key stakeholders that have a potential impact on recovery efforts and develop relationships. Encourage participation of all relevant agencies' senior and junior staff in joint training and planning sessions to foster relationship building, communication, trust, and appreciation for each other's roles.
Planning and Training	Integrate pre-disaster recovery planning (such as response, land use, hazard mitigation, and recovery planning) with other community planning (e.g., comprehensive, accessibility design, and capital improvement planning). Participate with state, MPO, and local disaster recovery planning initiatives to coordinate actions and build relationships. Conduct regional joint planning and exercises that will help efficiently prepare supplementary support resources. Test and evaluate pre-disaster plans through seminars, workshops, and exercises. Develop and implement recovery training and education as tool for building recovery capacity.
Documentation	Gather and maintain design drawings and specifications. Document configuration changes arising from construction, repairs, inspections, and alterations. Establish back-up document storage at alternate locations. Update plans and procedures based on experiences identified in After-Action Reports.
Recovery Legal Authority and Financing	Identify FEMA contacts and understand requirements for emergency funding and grant assistance programs for recovery. Identify and establish ongoing relationships with federal contacts such as FHWA District contacts. Understand which projects require federal project oversight, e.g., large emergency projects that over-task state resources.

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List of Acronyms

ABA	American Bar Association
AC	Area Command
AHMCT	Advanced Highway Maintenance and Construction Technology
AIP	Airport Improvement Program
APA	American Planning Association
BIA	Business Impact Analysis
CAPTA	Costing Asset Protection Transportation Agency
CBP	Customs and Border Protection
CBR	Chemical, Biological, Radiological
CDBG	Community Development Block Grant
CE	Categorical Exclusion
CEI	Construction Engineering and Inspection
CFR	Code of Federal Regulations
CIKR	Critical Infrastructure and Key Resources
COG	Council of Government
COOP	Continuity of Operations
DDIR	Detailed Damage Inspection Report
DNR	Department of Natural Resources
DOC	U.S. Department of Commerce
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DOJ	Department of Justice
DOL	Department of Labor
DOS	U.S. Department of State
DOT	Department of Transportation
DRC	Disaster Recovery Center
DRGR	Disaster Recovery Grant Reporting System
DRM	Disaster Recovery Manager
DSCA	Defense Support of Civil Authorities
DVA	Department of Veterans Affairs
EA	Environmental Assessment
EDA	Economic Development Administration
EIS	Environmental Impact Statement
EMAC	Emergency Management Assistance Compact
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
ER	Emergency Relief Program

ERFO	Emergency Relief for Federally Owned Roads
ERMS	Electronic Record Management System
ESA	Endangered Species Act
ESA	Economics and Statistics Administration
ESF	Emergency Support Function
ESFLG	Emergency Support Function Leadership Group
ETO	Emergency Transportation Operations
FCD	Federal Continuity Directive
FCO	Federal Coordinating Officer
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FEMA	Federal Emergency Management Agency
FRC	Federal Recovery Coordinator
GAO	Government Accountability Office
GIS	Geographical Information System
GSA	General Services Administration
HMGP	Hazard Mitigation Grant Program
HND	Highways for National Defense
HSPD	Homeland Security Presidential Directive
HUD	U.S. Department of Housing and Urban Development
HHS	Department of Health and Human Services
HQ	Headquarters
IA	Individual Assistance
IAA	Interagency Agreement
ICS	Incident Command System
IDOT	Illinois Department of Transportation
IHP	Individuals & Households Program
INF	Immediate Needs Funding
IP	Office of Infrastructure Protection
ITS	Intelligent Transportation Systems
JFO	Joint Field Office
LADOTD	Louisiana Department of Transportation and Development
LMRO	Lower Manhattan Recovery Office
LTCR	Long-Term Community Recovery
MARAD	Maritime Administration
MDOT	Michigan Department of Transportation
MnDOT	Minnesota Department of Transportation
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MPO	Metropolitan Planning Organization
MTA	Metropolitan Transportation Authority
MTS	Marine Transportation System
NDRF	National Disaster Recovery Framework
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NGO	Nongovernmental Organization
NICC	National Infrastructure Coordination Center
NIMS	National Incident Management System
NIPP	National Infrastructure Protection Plan
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration

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NPG	National Preparedness Goal/National Preparedness Guidelines
NPIAS	National Plan of Integrated Airport Systems
NPPD	National Protection Programs Directorate
NRCC	National Response Coordination Center
NPS	National Park Service
NRF	National Response Framework
NSA	National Shipping Authority
NTRS	National Transportation Recovery Strategy
NVOAD	National Voluntary Organizations Active in Disaster
NWS	National Weather Service
ODOT	Oklahoma Department of Transportation
OIG	Office of Inspector General
OPI	Organizational Performance Indicators
PA	Public Assistance Grant Program
PATH	Port Authority Trans-Hudson
PCE	Programmatic Categorical Exclusion
PCII	Protected Critical Infrastructure Information Program
PKEMRA	Post-Katrina Emergency Management Reform Act
PND	Ports for National Defense
PNP	Private Nonprofit
PPE	Personal Protective Equipment
PSA	Protective Security Advisor
RETCO	Regional Emergency Transportation Coordinator
RETREP	Regional Emergency Transportation Representative
RFP	Request for Proposals
RFQ	Request for Qualifications
RISC	Regional Interagency Steering Committee
RND	Railroads for National Defense
ROI	Return on Investment
RRF	Ready Reserve Force
RRIF	Railroad Rehabilitation & Improvement Financing
RSF	Recovery Support Function
RTPO	Regional Transportation Planning Organization
SAP	Safety Assessment Program
SATE	Special Assistant for Transportation Engineering
SBA	Small Business Administration
SBRM	Systems-Based Risk Management
SCO	State Coordinating Officer
SEOC	State Emergency Operations Center
SHOPP	State Highway Operation and Protection Program
SHPO	State Historical Preservation Office
SLSDC	St. Lawrence Seaway Development Corporation
SME	Subject-Matter Expert
SOP	Standard Operating Procedure
SOSP	Scope of Services Package
SCC	Sector Coordinating Council
SRC	State Recovery Coordinator
SSA	Sector-Specific Agencies
SSP	Sector-Specific Plan
STRACNET	Strategic Rail Corridor Network
STRAHNET	Strategic Highway Network

TCL	Target Capabilities List
TIP	Transportation Improvement Program
TMC	Transportation Management Center
TMS	Transportation Management System
TRO	Transitional Recovery Office
TSA	Transportation Security Administration
TSSSP	Transportation Systems Sector Security Plan
TVA	Tennessee Valley Authority
U.S.	United States
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
USPS	U.S. Postal Service
UTL	Universal Task List
VAL	Voluntary Agency Liaison
VOAD	Voluntary Agencies Active in Disaster
VTrans	Vermont Agency of Transportation
WisDOT	Wisconsin Department of Transportation

APPENDIX A: TOOLS AND RESOURCES COMPILED BY NCHRP PROJECT 20-59(33) RESEARCH TEAM

This appendix provides a listing of tools and resources that can assist in both the pre-event planning for recovery and for post-event recovery. The tools and resources are organized by the key tasks and decisions of pre-event recovery. Checklists, worksheets, and online toolboxes are listed first, followed by guidance and resource documents for each category.

CATEGORIES: TOOLS AND RESOURCES

Federal Initiatives and Guidance

Checklists, Worksheets, and Toolkits

Critical Infrastructure Protection and Resilience Toolkit
The U.S. Department of Homeland Security (DHS) created this online toolkit for infrastructure owners and operators to assist in incorporating key concepts of the National Infrastructure Protection Plan (NIPP) into day-to-day activities. The toolkit includes an exercise planning resource with tools to help plan a "tabletop" exercise to evaluate infrastructure protection and resilience and links to online reference materials and training resources. The toolkit can be found at:
http://www.learningservices.us/CriticalInfrastructureToolkit/

Business Impact Analysis Worksheet
The National Transportation Recovery Strategy (NTRS), designed to help transportation industry stakeholders and local, tribal, and state government officials prepare for and manage the transportation recovery process, recommends that a Business Impact Analysis (BIA) be done as part of pre-event recovery planning. The Federal Emergency Management Agency (FEMA) provides a Business Impact Analysis Worksheet on the ready.gov website at:
http://www.ready.gov/sites/default/files/documents/files/BusinessImpactAnalysis_Worksheet_0.pdf

Guidance and Resources

National Disaster Recovery Framework
Authors: Federal Emergency Management Agency (FEMA – OMB)
Department of Homeland Security (DHS)
Date Draft Published: February 5, 2010
http://www.fema.gov/pdf/recoveryframework/omb_ndrf.pdf

The National Disaster Recovery Framework (NDRF) provides guidance that enables effective recovery support to disaster-impacted states, tribes and local jurisdictions. It provides a flexible structure that enables disaster recovery managers to operate in a unified and collaborative manner. It also focuses on how best to restore, redevelop, and revitalize the health, social, economic, natural, and environmental fabric of the community and build a more resilient nation. The NDRF defines:

- Core recovery principles
- Roles and responsibilities of recovery coordinators and other stakeholders
- A coordinating structure that facilitates communication and collaboration among all stakeholders
- Guidance for pre- and post-disaster recovery planning

The Recovery Support Function (RSF) structure coexists with and builds upon the Emergency Support Functions (ESFs) under the National Response Framework (NRF). RSFs are different from ESFs in that they have different mission objectives, partnerships, approaches, time spans and organizational structure; additionally, the players and skill sets involved may be different.

Recovering from Disasters: The National Transportation Recovery Strategy
Authors: Federal Highway Administration (FHWA)
Date Published: September 2009
http://www.dot.gov/policy-initiatives/disaster-recovery/recovering-disasters-national-transportation-recovery-strategy

The National Transportation Recovery Strategy (NTRS) is designed to help transportation industry stakeholders and local, tribal, and state government officials prepare for and manage the transportation recovery process following a major disaster. The overall goal of the NTRS is to promote a recovery process for transportation networks—and subsequently of communities in general that results in a greater level of resilience. The NTRS provides general information on disaster management and the role of the federal government in transportation recovery.

National Response Framework
Authors: Department of Homeland Security (DHS)
Date Published: January 2008
http://www.fema.gov/pdf/emergency/nrf/nrf-core.pdf

The National Response Framework (NRF) is a comprehensive guide reflecting how the nation conducts immediate actions in an all-hazards response to save lives, prevent or minimize damage to property and the environment, and to meet basic human needs. The document is built on coordinating structures covering roles and responsibilities nationwide and describes best practices for incident management ranging from serious local events to large-scale terrorism or catastrophic natural disasters. Written for government executives, private-sector and nongovernmental organization (NGO) leaders, and emergency management practitioners, the NRF builds on the National Incident Management System (NIMS), which provides a template for managing incidents.

Transportation Systems Critical Infrastructure and Key Resources Sector-Specific Plan—NIPP
Authors: Department of Homeland Security (DHS)
Date Published: May 2007
http://www.dhs.gov/xlibrary/assets/nipp-ssp-transportation.pdf

This report is one of 17 Sector-Specific Plans (SSPs) that detail the application of the NIPP to each specific sector. Segmented into six key subsectors, the Transportation Systems Sector includes aviation, maritime, mass transit, highway, freight rail, and pipeline. Throughout the plan, emphasis is placed on a systems-based risk management (SBRM) strategy and its effectiveness for the NIPP. Also outlined are government agencies and their roles within the Sector-Specific Plan.

National Incident Management System (NIMS)
Authors: Department of Homeland Security (DHS)
Date Published: December 2008
http://www.fema.gov/emergency/nims/index.shtm

The NIMS provides a systematic, proactive approach to guide departments and agencies at all levels of government, nongovernmental organizations, and the private sector to work seamlessly to prevent, protect against, respond to, recover from, and mitigate the effects of incidents. The NIMS works hand in hand with the NRF. Whereas the NIMS provides the template for the management of incidents, the NRF provides the structure and mechanisms for a national-level policy for incident management.

Simplified Guide to the Incident Command System (ICS) for Transportation Professionals
Authors: Federal Highway Administration, Department of Transportation
Date Published: February 2006
http://www.ops.fhwa.dot.gov/publications/ics_guide/ics_guide.pdf

The Incident Command System (ICS) is a systematic tool used for the command, control, and coordination of an emergency response. The ICS allows agencies to work together using common terminology and operating procedures for controlling personnel, facilities, equipment, and communications at a single incident scene. The purpose of the guide to the ICS is to introduce the ICS to stakeholders who may be called upon to provide specific expertise, assistance, or material during highway incidents but who may be largely unfamiliar with the ICS's organization and operations.

Guide to Disaster Declarations Process
Authors: Federal Emergency Management Agency
Date Published: April 2011
http://www.fema.gov/pdf/rrr/dec_proc.pdf

The *Guide to Disaster Declarations Process* is based on the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988, which establishes a process for requesting and obtaining a Presidential disaster declaration. The guide defines the type and scope of assistance available from the federal government and sets the conditions for obtaining that assistance. An overview is provided on procedures to be used by Governors to request a declaration of disaster. The guide also encompasses hazard mitigation and the role it plays in allocating funds through a grant program.

National Preparedness Guidelines
Authors: Office of Management and Budget
Date Published: January 2011
http://www.whitehouse.gov/sites/default/files/omb/assets/procurement_guides/emergency_acquisitions_guide.pdf

Homeland Security Presidential Directive-8 (HSPD-8) of December 17, 2003 ("National Preparedness") directed the Secretary of Homeland Security to develop a national, domestic, all-hazards preparedness goal. The National Preparedness Guidelines (Guidelines) finalize development of the national preparedness goal and its related preparedness tools. The purposes of the Guidelines are the following:

- Organize and synchronize national (including federal, state, local, tribal, and territorial) efforts to strengthen national preparedness;
- Guide national investments in national preparedness;
- Incorporate lessons learned from past disasters into national preparedness priorities;
- Facilitate a capability-based and risk-based investment planning process; and
- Establish readiness metrics to measure progress and a system for assessing the nation's overall preparedness capability to respond to major events, especially those involving acts of terrorism.

Recovery Planning

Checklists, Worksheets, and Toolkits

Recovery Toolboxes and Checklists by Recovery Phase
The Puget Sound Transportation Recovery Annex (2011), a best practice example of a regional Transportation Recovery Plan, provides Recovery Toolboxes for each transportation sector—roadways, waterways, and airways—that include infrastructure assessments, mitigation strategies, and repair/replacement approaches. The toolboxes are found in Appendices E, F, and G of the Annex found at *http://www.seattle.gov/emergency/library/TransportationRCPTApprovedFinal.pdf*

Recovery checklists for each phase of recovery—short-, mid- and long-term—following a disaster organized by roadways, waterways, airways, and railways can be found in Appendix 1 (pages 16-26) of this Annex overview document: *http://psrc.org/assets/8642/Transportation_Recovery_Annex-Transp_handout_final_041012.pdf*

An executive summary of the Recovery Annex can be found at *http://www.apwa-wa.org/Uploads/CommitteeFiles/MPAC/Regional%20Transportation%20Recovery%20Annex%20Information%20Feb%202012.pdf*

Guidance and Resources

Recovering from Disasters: The National Transportation Recovery Strategy
Authors: Federal Highway Administration (FHWA)
Date Published: September 2009
http://www.dot.gov/policy-initiatives/disaster-recovery/recovering-disasters-national-transportation-recovery-strategy

The National Transportation Recovery Strategy (NTRS) is designed to help transportation industry stakeholders and local, tribal, and state government officials prepare for and manage the transportation recovery process following a major disaster. The overall goal of the NTRS is to promote a recovery process for transportation networks—and subsequently of communities in general that results in a greater level of resilience. The NTRS provides general information on disaster management and the role of the federal government in transportation recovery.

Planning for Post-Disaster Recovery and Reconstruction
Authors: American Planning Association, Federal Emergency Management Agency (FEMA)
Date: December 1998
http://www.fema.gov/library/viewRecord.do?id=1558

This document, #421 from the FEMA library, introduces planners to policies for rebuilding and recovery after disasters and provides guidance on how to plan for post-disaster reconstruction. Developed in partnership with the American Planning Association (APA), Chapters 3, 4, and 5 are available for download from the FEMA library with information provided for ordering the complete publication.

Planning for Post-Disaster Recovery: Next Generation
Authors: American Planning Association
Date: October 2010
http://www.planning.org/research/postdisaster/

An update to the 1998 Planning for Post-Disaster Recovery and Reconstruction Guide was begun in October 2010. Estimated to be a 3-year project, the current status, recovery news, case studies, and online information for practitioners are available at http://www.planning.org/research/postdisaster/

Disaster Response and Recovery Resource for Transit Agencies
Authors: Federal Transit Administration (FTA)
Date: August 2006
http://www.transit-safety.volpe.dot.gov/publications/safety/DisasterResponse/PDF/DisasterResponse.pdf

Prepared for the FTA, this report provides best practices and links to specific resources that address critical disaster elements such as emergency preparedness, disaster response, and recovery for transit agencies.

NCHRP Report 525: Surface Transportation Security—Volume 6: Guide for Emergency Transportation Operations
Authors: Lockwood, S., J. O'Laughlin, D. Keever, and K. Weiss
Date: 2005
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_525v6.pdf

This report outlines ways to assist transportation agencies in adopting the National Incident Management System (NIMS) with Emergency Transportation Operations (ETO) in an all-hazard, coordinated approach. This guide is intended for both senior managers/policy makers and for agency program managers with the first five sections designed for all readers. The document provides strategies and tactics for improving ETO in a subsequent section of the guide. Key challenges, guidance, and best practices are organized through tables, lists, and detailed descriptions throughout the document.

Tabletop Exercise Instructions for Planned Events and Unplanned Incidents/ Emergencies
Authors: Federal Highway Administration, Department of Transportation
Date: November 2007
http://www.ops.fhwa.dot.gov/publications/tabletopexercpe/index.htm

This FHWA-prepared document offers suggestions on how to test a transportation management plan through a tabletop exercise. It provides scenarios for organizations and key stakeholders to test plans through a facilitated scenario-based discussion. Tabletop exercises allow traffic management team officials to review the effect of certain event-specific action plans on other concurrent events. In addition, the tabletop exercise approach is offered as a way to train and familiarize personnel with their roles and responsibilities within the planned special event's transportation management plan.

Emergency Transportation Operations CD-ROM
Authors: Research and Innovative Technology Administration, Federal Highway Administration
Date: April 2008
http://www.its.dot.gov/its_publicsafety/index.htm

This CD-ROM from FHWA is a compilation of more than 40 resource documents arranged by focus areas: Traffic Incident Management, Traffic Planning for Special Events, and Evacuation and Disaster Planning.

Puget Sound Regional Transportation Recovery Annex
Authors: Puget Sound Region
Date: February 2011
http://www.seattle.gov/emergency/library/TransportationRCPTApprovedFinal.pdf

The Puget Sound Transportation Recovery Annex (Annex) provides a best practice example of a regional Transportation Recovery Plan. The Annex supplements the Puget Sound Regional Catastrophic Coordination Plan and provides recommended guidelines for coordinating multijurisdictional regional transportation system recovery in the Puget Sound Region after a catastrophic incident. This Annex offers general guidelines on regional multijurisdictional coordination and priority setting for the recovery of transportation networks and includes appendices that can be used as toolboxes for traffic mitigation strategies, waterway alternatives, and bridge and roadway reconstruction. These appendices provide a multimodal guide for implementing strategies consistent with regionally available abilities and resources that will facilitate restoration of critical transportation links.

An executive summary of the Recovery Annex can be found at *http://www.apwa-wa.org/Uploads/CommitteeFiles/MPAC/Regional%20Transportation%20Recovery%20Annex%20Information%20Feb%202012.pdf*

Vulnerability Assessment/Prioritization

The following resources and tools provide guidance in how to identify, prioritize, document, and plan for the recovery of transportation critical infrastructure. They can assist in answering the key questions:

- Which infrastructure or key facilities are most at risk?
- What infrastructure is critical to operations and to community?
- Are there any alternatives available for the infrastructure?

Checklists, Worksheets, and Toolkits

Transportation Critical Infrastructure Asset List
Transportation infrastructure and facilities asset categories have been identified by the FTA in Transit Security Design Considerations (2004) and AASHTO in A Guide to Highway Vulnerability Assessment for Critical Asset Identification and Protection (2002). The AASHTO Guide to Highway Vulnerability Assessment was developed as a tool for state departments of transportation (DOTs) to assess the vulnerabilities of their physical assets and to assist in developing possible mitigations to address the vulnerability identified. Transit Security Design Considerations provides an overview of the major assets of transit systems—bus and rail vehicles, transit infrastructure, and communications—as well as a preliminary assessment of the vulnerabilities to various methods of attack inherent to each asset.

Transportation Critical Infrastructure Assets

Highway Critical Assets

INFRASTRUCTURE	FACILITIES	EQUIPMENT	PERSONNEL
▪ Arterial Roads ▪ Interstate Roads ▪ Bridges ▪ Overpasses ▪ Barriers ▪ Roads Upon Dams ▪ Tunnels	▪ Chemical Storage Areas ▪ Fueling Stations ▪ Headquarters Buildings ▪ Maintenance Stations/Yards ▪ Material Testing Labs ▪ Ports of Entry ▪ District/Regional Complexes ▪ Rest Areas ▪ Storm Water Pump Stations ▪ Toll Booths ▪ Traffic Operations Centers ▪ Vehicle Inspection Stations ▪ Weigh Stations	▪ Hazardous Materials ▪ Roadway Monitoring ▪ Signal & Control Systems ▪ Variable Messaging System ▪ Vehicles ▪ Communications Systems	▪ Contractors ▪ Employees ▪ Vendors ▪ Visitors

Source: *AASHTO Guide to Highway Vulnerability Assessment for Critical Asset Identification and Protection*, May 2002

Transit Agency Assets

INFRASTRUCTURE	FACILITIES	EQUIPMENT	PERSONNEL
▪ Elevated Bridges and Structures ▪ Tunnels and Pedestrian Underpasses	▪ Transit Stations ▪ Transit Stops ▪ Operations Control Centers ▪ Administrative Facilities ▪ Garages, Yards, and Maintenance Facilities ▪ Power Substations	▪ Right-of-Way, Track and Signals ▪ Communications Relays	▪ Contractors ▪ Employees ▪ Vendors ▪ Passengers ▪ Visitors

Source: Adapted from FTA Transit Security Design Considerations, 2004

Hazard Impact Analysis Worksheet

Hazard analysis involves identifying the hazards that potentially threaten an asset and analyzing them individually to determine the degree of threat that is posed by each. This information is then used in the development of both mitigation and emergency plans. It

indicates which hazards merit special attention, what actions might be taken to reduce the impact of those hazards, and what resources are likely to be needed.

FEMA has developed worksheets for profiling hazards as part of vulnerability analysis that can be found in this summary of FEMA training on hazards at *http://training.fema.gov/EMIWeb/edu/docs/raem/Readings%20D.doc*

Hazard Impact Analysis Worksheet

Hazard: _____

Frequency of Occurrence: ☐ *Highly likely* (Near 100% probability in the next year) ☐ *Likely* (Between 10% and 100% probability in the next year, or at least one chance in the next 10 years) ☐ *Possible* (Between 1% and 10% probability in the next year, or at least one chance in the next 100 years) ☐ *Unlikely* (Less than 1% probability in the next 100 years) *Seasonal pattern?* ☐ No ☐ Yes. Specify season(s) when hazard occurs: _____
Potential Impact: ☐ *Catastrophic* (shutdown of critical facilities for 1 month or more; more than 50% of property severely damaged) ☐ *Critical* (Injuries or illness resulting in permanent disability; shutdown of critical facilities for at least 2 weeks; 25% to 50% of property severely damaged) ☐ *Limited* (Temporary injuries; shutdown of critical facilities for 1-2 weeks; 10% to 25% of property severely damaged) ☐ *Negligible* (Injuries treatable with first aid; shutdown of critical facilities for 24 hours or less; less than 10% of property severely damaged) *Are any areas or facilities more likely to be affected (e.g., air, water, or land; infrastructure)? If so, which?*
Speed of Onset: 1. Minimal or no warning 2. 6 to 12 hours warning 3. 12 to 24 hours warning 4. More than 24 hours warning
Potential for Cascading Effects? ☐ No ☐ Yes. Specify effects:

Source: Adapted from FEMA Hazards training materials.

Prioritization Factors Table

The AASHTO Guide to Highway Vulnerability Assessment was developed as a tool for state DOTs to assess the vulnerabilities of their physical assets and to assist in developing possible mitigations to address the vulnerability identified. The vulnerability assessment process presented in the guide is derived from information compiled from state, federal, and international agencies and their personnel. Appendices to the AASHTO Guide to Highway Vulnerability Assessment contain worksheets reproduced from the full document for critical asset factor values and scoring, vulnerability factors and scoring, and protection countermeasures information. The appendices can be found online at *http://security.transportation.org/sites/security/docs/guide-VA_Appendices.pdf*

Included in the appendices is a list identifying transportation infrastructure and facilities asset categories and a prioritization factors table (reproduced herein). The factors range from "extremely important" (5) to "less important" and are based on the survey done for the AASHTO Guide.

Prioritization Factors Table

Critical Asset Factor	Value	Description/Considerations
Emergency Response Impact		Does route directly serve hospitals, resource points of distribution, etc.? Is route a previously identified emergency response route?
Transportation Lifeline	3	Is the asset a transportation lifeline?
Evacuation or Response Efforts	3	Is the asset required for evacuation or response?
Public Service		
Government Continuity	3	Is the asset necessary for maintaining government continuity? Does route directly serve city/county/state agencies essential for government continuity?
Military Importance	3	Is the asset important for military purposes? Does the route directly serve military bases and/or facilitate movement of military resources?
Symbolic Value	3	Does the asset have symbolic value?
Loss and Damage Consequences		
Economic Impact	3	Will damage to the asset have an impact on the means of living or the resources and wealth of the region or state? Does this asset serve major employment or trade centers? Does this asset serve ports?
Environmental Impact	3	Will the damage to the asset have an ecological impact of altering the environment?
Communication Impact	3	Is communication dependent on the asset? Does this asset support critical communication infrastructure facilities or operations?
Operational/Functional		
Functional Importance	3	Is there an overall value in the asset performing or staying operational?
Replacement/Downtime	3	Will the damage to the asset cause significant replacement downtime?
Available Alternative	3	Is this the only asset that can perform its primary function? Is there a substitute that is designated to take the place of the asset, if necessary, to perform the same or similar functions?

Intermodal/Freight Connections	3	Does this connect to intermodal transportation hubs? Does this connect to ports?
Transit Services	3	Does this provide relief to congestion and traffic mitigation? Is it or will it be a transit route or alternative transit route?

Source: Adapted from AASHTO Guide to Highway Vulnerability Assessment.

Information Needs for Prioritization List

The Puget Sound Regional Recovery Transportation Annex modified the AASHTO prioritization guidelines on recovery planning best practices and stakeholder input and included a description of high-priority regional transportation asset factors and a list of Prioritization Components information to assist in the prioritization process. It was recommended that local authorities should obtain those items listed as part of the pre-event "information gathering" planning.

Information Gathering Needs: Prioritization Components
Emergency Response – Map of Hospitals Map of Resource Points of Distribution Map of Emergency Response Routes and/or Lifelines
Government Continuity – Location of government agencies
Military Importance – Map of military bases and routes that serve bases
Available Alternate – Map of alternative routes and status (e.g., capacity)
Communications Dependency – Map of utilities located within rights-of-way that are affected by disruption
Economic Impact – Local Economics and Finance Departments to provide information
Intermodal Freight Connections – Map of intermodal facilities and status of connecting modes (ports, rail, trucking, etc.)
Transit Services – Map of transit service regions

Source: Adapted from Puget Sound Regional Recovery Transportation Annex, 2011.

Guidance and Resources

A Guide to Highway Vulnerability Assessment for Critical Asset Identification and Protection

Authors: AASHTO, Science Applications International Corporation (SAIC)
Date: May 2002
http://security.transportation.org/sites/security/docs/guide-VA_FinalReport.pdf

The AASHTO Guide to Highway Vulnerability Assessment was developed as a tool for state DOTs to assess the vulnerabilities of their physical assets such as bridges, tunnels, roadways, and inspection and traffic operation facilities and to develop possible countermeasures to address the vulnerability identified. The guide includes an approach for identifying critical infrastructure assets and suggests criteria such as conditions, concerns, consequences, and capabilities, by which to prioritize the identified critical assets. The appendices to the AASHTO Guide to Highway Vulnerability Assessment contain worksheets reproduced from the full document for critical asset factor values and scoring, vulnerability factors and scoring, and protection countermeasures information.

NCHRP Report 525: Surface Transportation Security—Volume 15: Costing Asset Protection: An All Hazards Guide for Transportation Agencies (CAPTA)

Authors: Science Applications International Corporation, PB Consult
Date: May 2009
http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_525v15.pdf

Volume 15: Costing Asset Protection (CAPTA) of NCHRP Report 525 provides a guide for developing system-wide budget estimates for an all hazards approach to mitigation rooted in the National Incident Management System. It uses asset type and profiles to identify recommended measures and accompanying costs. States that already employ a comprehensive and fully integrated AMS will have already compiled the necessary information to execute the evaluation program. The process is applicable to natural hazards situations as part of pre-event recovery planning. The CAPTA Spreadsheet and an online Help tool is available at: *http://www.trb.org/Main/Blurbs/160337.aspx*

NCHRP Report 632: An Asset-Management Framework for the Interstate Highway System

Authors: Cambridge Systematics, Inc.; Applied Research Associates, Inc.; Arora Associates, Inc; KLS Engineering; PB Consult, Inc.; and Louis Lambert
Date: May 2009
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_632.pdf

NCHRP Report 632 provides a framework for applying asset-management principles and practices to managing highway system assets. The report describes data needed to support asset-management decisions, how current data inventories may be employed, and cost-effective data-collection schemes. The report also considers available decision-support tools that can be used in applying asset-management principles and practices.

A-14 A Pre-Event Recovery Planning Guide for Transportation

Asset Management
Authors: Federal Highway Administration (FHWA)
Date updated: August 30, 2010
http://www.fhwa.dot.gov/infrastructure/asstmgmt/resource.cfm

This web resource is an asset management overview prepared by the FHWA with extensive coverage on focus areas provided through links to other sections within the website. Focus areas include management of bridges, tunnels, culverts, and pavements; preservation and evaluation and economic investment; memos, publications, and training courses; and events within the agency. Features, contacts, and sponsors are also highlighted in this resource.

Hazards Resources
Information on potential hazards, including probability and possible effects, can be obtained from FEMA, State Emergency Management and Civil Defense Agencies, the National Weather Service (NWS), the Environmental Protection Agency (EPA), the U.S. Geological Survey, the U.S. Army Corps of Engineers, and the Department of Natural Resources (DNR). See FEMA Region II Hazard Mitigation Risk Toolkit at: *http://www.fema.gov/about/regions/regionii/toolkit_risk.shtm*

FEMA 433—Using HAZUS-MH for Risk Assessment
Authors: Federal Emergency Management Agency (FEMA)
Date Updated: August 11, 2010
http://www.fema.gov/plan/prevent/hazus/dl_fema433.shtm

HAZUS-MH is a risk assessment software program provided by FEMA for analyzing potential losses from floods, hurricane winds, and earthquakes. HAZUS-MH takes into account various impacts such as physical damage (damage to residential and commercial buildings, schools, critical facilities, and infrastructure); economic loss (lost jobs, business interruptions, and repair and reconstruction costs); and social impacts (impacts to people, including requirements for shelters and medical aid). This web source provides access to a how-to guide for preparing standardized, scientifically based risk assessments with the HAZUS-MH software. The guide was prepared by FEMA on the basis of field-implemented HAZUS-MH risk assessment pilot projects across the country that are responding to the requirements of the Disaster Mitigation Act of 2000 (DMA 2000). This comprehensive guide is intended for users who have had exposure to HAZUS-MH and are interested in using the software to support risk assessment studies. HAZUS-MH can be found at: http://www.fema.gov/hazus/hz_index.shtm

iCat Storm Damage Estimator
Authors: iCat
Date Published: 2009
http://www.icatdamageestimator.com/

This website was created by iCat to provide easy access to historical hurricane damage information. This interactive resource is a comprehensive searchable interface to find

damage estimates for all major storms in the United States from 1900 to the present day. The website encompasses a video explanation of how to use the site, including the extensive searchable methods available. The website includes the capacity to sort searches by storm year, name, place of landfall, and category, as well as to do quick searches. Options for views include satellite, map, terrain, and Google earth, as well as map tools for selecting specific areas to show what storms occurred in any particular area. Searches can be bookmarked, and there is an option for exporting data and sharing from the estimator via email, print, Google Earth, or in a spreadsheet file.

FEMA Map Service Center
Authors: Federal Emergency Management Agency (FEMA)
http://msc.fema.gov/webapp/wcs/stores/servlet/FemaWelcomeView?storeId=10001&catalogId=10001&langId=-1

This source provides map information for a variety of users affected by floods, including homeowners and renters, real estate and flood determination agents, insurance agents, engineers and surveyors, and federal and exempt customers. There are flood maps, databases, map viewers, documents, and publications providing comprehensive information. Further aspects of the site include FEMA-issued flood maps available for purchase, definitions of FEMA flood zone designations, and information about FIRMettes, a full-scale section of a FEMA Flood Insurance Rate Map (FIRM) that users can create and print at no charge.

FEMA Multi-Hazard Mapping Initiative (MMI)—HazardMaps
Authors: Federal Emergency Management Agency (FEMA)
http://www.fema.gov/hazard/index.shtm

This subsection of FEMA's website covers disasters and maps including hurricanes and floods, and finding information on declared disasters and emergencies. There are links to extensive information on different types of disasters and historical data on Presidential declarations. The map service center provides assistance on all maps available through FEMA and the different audiences that might utilize them from homeowners to insurance agents to engineers.

Prioritization Analysis Tool for All-Hazards
Authors: Sandia National Labs
http://www.sandia.gov/mission/homeland/factsheets/PATH%20one-pager%20FINAL.pdf

This one-page brochure, provided by Sandia National Laboratories, provides the basic overview for the PATH tool (Prioritization Analysis Tool for All-Hazards), a spreadsheet-based decision support tool designed to minimize consequences of wide area disasters. Citing an example scenario, capabilities, and diagrams, the brochure provides a condensed introduction to the tool.

HAZARDS TOOLS

Tool	Description and Web Link
GIS Practices for Transportation	GIS website developed by FHWA's Resource Center provides information on relevant GIS issues for transportation planners and contains links to other state, local, and government GIS websites *http://www.gis.fhwa.dot.gov/default.asp*
State and Local GIS Practices	Gateway to numerous GIS transportation applications currently being employed across the nation *http://www.gis.fhwa.dot.gov/statepracs.asp*
Natural Hazards Support System (NHSS)	The Natural Hazards Support System (NHSS) is being developed by the USGS Rocky Mountain Geographic Science Center (RMGSC) to aid in monitoring, responding to, and analyzing natural hazard events. NHSS meets these needs by combining a wide range of natural hazards events into a single geo-spatial, web-enabled viewer, allowing users to easily see the geospatial relationship(s) of different natural hazard events and contributes to the analysis of their potential impacts *http://nhss.cr.usgs.gov/*
Update of U.S. Precipitation Frequency Estimates (NOAA)	The updates published as subsequent Volumes of NOAA Atlas 14 “Precipitation-Frequency Atlas of the United States” on results will allow DNR and others to review the potential of flooding risks based on the updated hydraulic information. *http://www.nws.noaa.gov/oh/hdsc/currentpf.htm*
USGS Real-Time Water Data for the Nation	Real-time data typically are recorded at 15-60 minute intervals, stored onsite, and then transmitted to USGS offices every 1 to 4 hours, depending on the data relay technique used. Recording and transmission times may be more frequent during critical events. NHSS updates this information every hour. *http://waterdata.usgs.gov/nwis/rt*
Volcanoes Hazards Program	The Volcano Hazards Program monitors active and potentially active volcanoes, assesses their hazards, responds to volcanic crises, and conducts research on how volcanoes work to fulfill a Congressional mandate (P.L. 93-288) that the USGS issue "timely warnings" of potential volcanic hazards to responsible emergency-management authorities and to the populace affected. *http://volcanoes.usgs.gov/*
Earthquake Hazards Program	U.S. Geological Survey Earthquake Hazards Program monitors earthquake activity and provides information and tools for federal, state, and local organizations. *http://earthquake.usgs.gov/*
ShakeMaps	ShakeMap is a product of the U.S. Geological Survey Earthquake Hazards Program in conjunction with regional seismic network operators. ShakeMap sites provide near-real-time maps of ground motion and shaking intensity following significant earthquakes. These maps are used by federal, state, and local organizations, both public and private, for post-earthquake response and recovery, public and scientific information, as well as for preparedness exercises and disaster planning. *http://earthquake.usgs.gov/earthquakes/shakemap/*

ShakeCast	Critical users (lifeline utilities, for example) can receive automatic notifications within minutes of an earthquake indicating the level of shaking and the likelihood of impact to their own facilities. ShakeCast "Lite" delivers maps of areas affected by an earthquake. Areas of interest can be defined, and shaking thresholds can be set to trigger automatic notifications. Easy to integrate with in-house systems. *http://earthquake.usgs.gov/research/software/shakecast/*
WaterWatch ToolKit	U.S. Geological Survey (USGS) collects hydrologic and water-quality information and provides access to water data, publications, and maps. The WaterWatch Toolkit provides streamflow conditions maps that can be downloaded and/or incorporated into other systems. *http://waterwatch.usgs.gov/supports/index.php?id=wwtool*
Seismic Design Maps and Tools for Engineers	U.S. Geological Survey (USGS) provides maps, data, and tools for engineers interested in seismic design of buildings and bridges. *http://earthquake.usgs.gov/hazards/designmaps/*
Landslide Monitoring	USGS Landslide Hazards Program monitors selected landslides and hillsides. *http://landslides.usgs.gov/monitoring/*
FEMA Earthquake Resources Catalog	This FEMA catalog provides an overview of more than 80 National Earthquake Hazards Reduction Program publications and resources available including earthquake training resources. *http://www.fema.gov/library/viewRecord.do?id=3538*
Catalog of FEMA Wind, Flood, and Wildfire Publications, Training Courses, and Workshops	This FEMA catalog contains a listing with brief descriptions of publications, courses, and workshops developed by the Building Science Section of FEMA's Federal Insurance and Mitigation Administration (FIMA). Publications include recovery advisories (hurricane, tornado, and wildfire), Mitigation Assessment Team (MAT) reports (hurricanes and tornadoes), natural hazard Risk Management Series (RMS) publications, technical bulletins, brochures, training courses, and workshops. *http://www.fema.gov/library/viewRecord.do?id=3184*
Consequence-Based Top Screen (CTS) Methodology	The CTS methodology, developed by the Dam Sector, identifies critical facilities by focusing on potential consequences in the analysis (i.e., those high-consequence facilities, the failure or disruption of which could be potentially associated with the highest possible impact among assets). Because the approach decouples the analysis from threat and vulnerability components of the risk process, it can serve as an effective all-hazards preliminary prioritization scheme. *http://www.dhs.gov/files/programs/gc_1260541882284.shtm*

Repair/Replacement

Establishing the repair/replace criteria before an event occurs can expedite the recovery. The following resources and tools can assist in answering the key repair/replacement questions:

- Should the infrastructure be replaced?
- What options are there for repairing the infrastructure?
- Should infrastructure be relocated?
- Are there historic preservation or environmental concerns that need to be addressed?

Checklists, Worksheets, and Toolboxes

Typical Transportation Repair/Replacement Elements by Recovery Phase

A table of transportation infrastructure repair and replacement elements categorized by recovery phase was adapted from Puget Sound Recovery Annex, 2011 and provided herein.

Repair/Replacement Elements by Recovery Phase

Repair and Replacement Elements			
Repair/Replace Elements	**Phase**		
	Short-Term	**Mid-Term**	**Long-Term**
Assess bridges and roadway structures	√	√	√
Prioritize segment restoration	√	√	√
Repair bridges and roadway structures	√	√	√
Replace bridges and roadway structures		√	√
Coordinate with utility purveyors for utilities in rights-of-way	√	√	√
Provide engineering contract mechanisms			√

Source: Adapted from Puget Sound Recovery Annex, 2011.

Example Damage Classification System

One of the earliest challenges to recovery is gaining an understanding of the extent of the damage along with what is required to repair and restore the damaged infrastructure. The infrastructure damage classification example with typical repair options for each level of damage that is provided herein is adapted from Emergency Damage Assessment (EDA) by MCEER, University at Buffalo for USDOT's Federal Highway Administration as part of Project 106.

Example Damage Classification System

Category	Description and Repair Option	Functionality
No Damage	No notable damage; evidence of some impact may be present	No loss of functionality
Minor Damage	Some visible signs of damage; repairs can be made under regular maintenance program	Little or no loss of functionality
Moderate Damage	Visible and significant signs of damage; repairs or stabilization likely to be completed under emergency traffic	Some loss of functionality
Major Damage	Life safety is threatened under service loads; emergency repairs, stabilization or replacement required	Considerable to total loss of functionality
Collapse	Structure failed, moved off supporting foundation, or collapsed. Rebuilding or replacement required.	Total loss of functionality

Source: Adapted from Emergency Damage Assessment (EDA), MCEER, University of Buffalo.

WSDOT Training for First Inspections
Training for first inspections is currently available by using the video and manual, "Student Manual to Accompany Training Video on Post-earthquake Safety Evaluation of Bridges State of Washington" posted on the WSDOT website:
ftp://ftp.wsdot.wa.gov/incoming/Nisqually%20Post%20EQ%20Inspection/

Safety Assessment Program (SAP) Evaluation Training Manual
California Emergency Management Program for registered professionals—licensed engineers, architects, geologists, and building inspectors—trained in safety evaluation of infrastructure in an aftermath of a disaster. A SAP training manual for evaluators is available at
http://www.calema.ca.gov/Recovery/Documents/Safety%20Assessment%20Program/SAP%20Evaluator%20Student%20Manual%202011.pdf

An overview of SAP with other materials is located at
http://www.calema.ca.gov/Recovery/Pages/Safety-Assessment.aspx

Information Tools to Improve Post-Earthquake Prioritization of Bridge Inspections
http://www.wsdot.wa.gov/Research/Reports/600/602.1.htm
WSDOT tools and procedures to estimate the likelihood of slight (or greater) bridge damage based on the intensity of earthquake shaking (obtained from ShakeMaps) and on each bridge's location, year of construction, and bridge type and information contained in HAZUS software for predicting the lowest level of damage.

Checklist for Tornado/Hurricane Damaged Structure Inspection
This online checklist from the American Institute of Architects (AIA) describes the damage signs that should be noted for a wood frame structure (exterior and interior), steel frame or load bearing walls, or concrete frame or slab after a structure has been damaged during any of the wind storms—tornado, hurricane, or high winds. Available at
http://www.aia.org/about/initiatives/AIAS075274?dvid=&recspec=AIAS075274

A related damage assessment worksheet is available at
http://www.aia.org/aiaucmp/groups/aia/documents/pdf/aias077907.pdf

FHWA Detailed Damage Inspection Report (DDIR) Form
The FHWA DDIR form FHWA-1547 can be found online at
http://www.fhwa.dot.gov/reports/erm/fhwa1547.pdf

Guidance and Resources for Repair/Replacement

Recommended Post Earthquake Evaluation and Repair Criteria for Welded Steel Moment-Frame Buildings (FEMA 352)
Authors: Federal Emergency Management Agency (FEMA)
Date Published: 2000
http://www.fema.gov/plan/prevent/earthquake/pdf/fema-352.pdf

This report provides recommendations for performing inspections to detect damage in steel moment-frame buildings following an earthquake; evaluating the damaged buildings' safety in a post-earthquake environment; and repairing damaged buildings. Chapters cover inspection and classification of damage; preliminary post-earthquake assessment; detailed post-earthquake evaluations; and post-earthquake repair. The appendices include procedures for performance evaluation; sample placards that may be used to post buildings following preliminary post-earthquake evaluations; and sample inspection forms that may be used to record damage detected in beam-column connections as part of a detailed post-earthquake inspection program.

The Repair of Earthquake Damaged Concrete and Masonry Wall Buildings (FEMA 308)
Authors: Federal Emergency Management Agency (FEMA)
Date Published: 1998
http://www.fema.gov/library/viewRecord.do?id=1533

This document provides practical guidance for the repair and upgrade of earthquake-damaged concrete and masonry wall buildings. Target audiences include design engineers, building owners and officials, insurance adjusters, and government agencies. The publication contains sections on performance-based repair design, repair technologies, categories of repair, and nonstructural considerations. The last section includes repair guides, which provide outline specifications for typical repair procedures.

DAMAGE ASSESSMENT TOOLS

Tool	Description and Web Link
iCat Storm Damage Estimator	iCat provides easy access to historical hurricane damage information. This interactive resource is a comprehensive searchable interface for finding damage estimates for all major storms in the United States from 1900 to the present day. The website encompasses a video explanation of how to use the site, including the extensive searchable methods available. The website includes sorting searches by storm year, name, place of landfall, category, as well as quick searches. Options for views include satellite, map, terrain, and Google earth, as well as map tools for selecting specific areas to show what storms occurred in any particular area. Searches can be bookmarked, and there is an option for exporting data and sharing from the estimator via email, print, Google Earth, or in a spreadsheet file. *http://www.icatdamageestimator.com/*
FEMA Map Service Center	FEMA provides map information for a variety of users affected by floods, including homeowners and renters, real estate and flood determination agents, insurance agents, engineers and surveyors, and federal and exempt customers. There are flood maps, databases, map viewers, documents and publications providing comprehensive information. Further aspects of the site include FEMA-issued flood maps available for purchase, definitions of FEMA flood zone designations, and information about FIRMettes, a full-scale section of a FEMA Flood Insurance Rate Map (FIRM) that users can create and print at no charge. *http://msc.fema.gov/webapp/wcs/stores/servlet/FemaWelcomeView?storeId=10001&catalogId=10001&langId=-1*

Information Tools to Improve Post-Earthquake Prioritization of Bridge Inspections	WSDOT tools and procedures to estimate the likelihood of slight (or greater) bridge damage based on the intensity of earthquake shaking (obtained from ShakeMaps) and on each bridge's location, year of construction, bridge type, and information contained in HAZUS software for predicting the lowest level of damage. *http://www.wsdot.wa.gov/Research/Reports/600/602.1.htm*
ASCE Post-Disaster Assessment Manual	The ASCE Post-Disaster Assessment Manual provides general guidance for the formation and operation of ASCE post-disaster assessment teams (assessment team or team).The primary purpose of ASCE post-disaster assessments is to evaluate the behavior of various engineered facilities under extreme conditions and to learn from the behaviors observed. The goal of these assessments is to document lessons learned regarding the causes of failures, restoration efforts, restoration times, and success stories. The document addresses the process for making the decision to launch an assessment as well as outlining the overall purpose, funding, and operation of the team effort so that assessment teams can be assembled, assessments conducted, and findings reported in a timely manner. *http://www.nehrp.gov/pdf/ASCEPost-DisasterManual.pdf*
ATC-45 Field Manual: Safety Evaluation of Buildings After Windstorms and Floods	The ATC-45 Field Manual provides guidelines and procedures to determine whether damaged or potentially damaged buildings are safe for use after wind storms or floods, or if entry should be restricted or prohibited. Formatted as an easy-to-use pocket guide, the Manual is intended to be used by structural engineers, building inspectors, and others involved in post-disaster building safety assessments. Advice is provided on evaluating structural, geotechnical, and nonstructural risks. Also included are procedures for Rapid Safety Evaluation, procedures for Detailed Safety Evaluation, information on how to deal with owners and occupants of damaged buildings, information on field safety for those making damage assessments, and example applications of the procedures. *https://www.atcouncil.org/Postdisaster-Safety-Evaluation-of-Buildings/Field-Manual-Safety-Evaluation-of-Buildings-after-Wind-Storms-and-Floods/flypage.tpl.html*
Post-Earthquake Damage and Safety Evaluation of Buildings	The ATC-20 product series contains guidelines and related materials for post-earthquake evaluation and repair of damaged buildings. The series is offered for sale on the Applied Technology Council (ATC) website, and includes all products in the ATC-20 Series and reports prepared under the ATC-43 project. Subjects in the ATC-20 series include basic procedure manuals, a field manual, case studies, a training slide set, and a tech brief. Documents prepared under the ATC-43 project provide guidance on in-depth engineering evaluation and repair of earthquake-damaged mason-wall buildings and concrete-wall buildings (FEMA 306, FEMA 307, FEMA 308), which are collectively available on the ATC-43 CD. *https://www.atcouncil.org/vmchk/Postearthquake-Damage-and-Safety-Evaluation-of-Buildings/View-all-products.html*
Evaluation of Earthquake-Damaged Concrete and Masonry Wall Buildings, Basic Procedures Manual (FEMA 306)	FEMA 306 was developed for and is focused on assessment and repair of earthquake-damaged buildings. The document provides practical criteria and guidance for buildings consisting of concrete or masonry bearing walls and frames with concrete or masonry infill panels. *http://www.fema.gov/library/viewRecord.do?id=1651*
Evaluation of Earthquake-Damaged Concrete and Masonry Wall Buildings, Technical Resources (FEMA 307)	This document provides background and theoretical information to be used in conjunction with FEMA 306. Analytical and experimental findings are included, as well as information on the Component Damage Classification Guides.*http://www.fema.gov/library/viewRecord.do?id=1652*

Recommended Postearthquake Evaluation and Repair Criteria for Welded Steel Moment-Frame Buildings (FEMA 352)	This report provides recommendations for performing inspections to detect damage in steel moment-frame buildings following an earthquake; evaluating the damaged buildings' safety in a postearthquake environment; and repairing damaged buildings. Chapters cover inspection and classification of damage; preliminary postearthquake assessment; detailed postearthquake evaluations; and postearthquake repair. The appendices include procedures for performance evaluation; sample placards that may be used to post buildings following preliminary postearthquake evaluations; and sample inspection forms that may be used to record damage detected in beam-column connections as part of a detailed postearthquake inspection program. *http://www.fema.gov/plan/prevent/earthquake/pdf/fema-352.pdf*
Post Earthquake Investigation Field Manual for the State of Kentucky	The Manual provides a rapid and efficient method of inspecting bridge structures after an earthquake. Primary users are intended to be first-line transportation personnel who initially reach the bridge sites. *http://www.ktc.uky.edu/Reports/KTC_06_30_SPR_234_01_1F.pdf*
Basic Techniques for Quick and Rapid Post-Earthquake Assessments of Building Safety	This work presents two single and direct methods designed for post-earthquake building inspections and safety classifications in small-to-medium size towns stricken by a damaging earthquake. The first Post-Earthquake Building Safety Assessment (PEBSA) method is an easy way to achieve general and approximated initial information on damage distribution and to detect heavily damaged and unsafe constructions (4 and 5 damage degree in EMS scale). These early data are necessary to emergency assistance, the local disaster statement, external aid requesting, and organizing rapid building inspections. The second method, named Rapid-PEBSA, follows conventional approaches for post-earthquake safety inspections in seismic-prone countries (USA, Japan, Italy). *http://www.narpimed.org/wp-content/uploads/Paper-3-post-EQ.pdf*

Temporary Structure/Traffic Detours: Short-Term Recovery

Short-term recovery efforts often overlap with response and focus on providing essential services and re-establishing critical transportation routes. To quickly restore movement to an affected area, temporary solutions can be put in place such as installing temporary bridges or roadways or offering alternate modes of transportation. The following resources and tools can assist in answering the key pre-event short-term recovery questions:

- What options are there for traffic detours?
- Can a temporary structure be used? What temporary structures are available to be used?
- What actions can be taken now to prepare?

Checklists, Worksheets, and Toolboxes

Transportation Mitigation Strategies Summary
The Puget Sound Recovery Annex includes an overview of transportation mitigation strategies organized by the phase of the recovery effort in which they usually occur. The overview is included below. A discussion of each strategy can be found in the Annex at *http://www.seattle.gov/emergency/library/TransportationRCPTApprovedFinal.pdf*

Transportation Mitigation Strategies			
Strategies	**Recovery Phases**		
	Short-Term	**Mid-Term**	**Long-Term**
Increase Capacity on Existing Lanes			
Operate Contraflow Lanes	√	√	√
Utilize Reversible Lanes	√	√	√
Restrict Lanes for HOV or BAT	√	√	√
Provide HOV Bypass at Bottlenecks	√	√	√
Utilize the Shoulder of a Roadway as an Additional Traffic Lane	√	√	√
Eliminate/Restrict On-Street Parking	√	√	√
Reduce Lane Widths to Accommodate Additional Lanes	√	√	√
Ramp Metering	√	√	√
Increase Transit Service	√	√	√
Increase Ferry Service	√	√	√
Improve Transportation Incident Management	√	√	√
Implement Traffic Management Technology	√	√	√
Change Signal Timing to Accommodate Changed Travel Patterns	√	√	√
Reprioritize Current Transportation Projects	√	√	√
Divert or Redirect Traffic			
Revise Transit Routes	√	√	√
Construct Bypass Roadway	√	√	√
Close Selected Freeway On/Off Ramps	√	√	√
Relocate Ferry Service		√	√
Manage Truck Usage	√	√	√
Designate Emergency Responder Routes	√	√	√
Convert Non-Motorized Trails to Restricted Use			√
Demand Management			
Telecommuting	√	√	√
Staggered Work Shifts			√
Compressed Work Week	√	√	√
Passenger-Only Ferry Service	√	√	√
Congestion Pricing	√		
Vanpool/Carpool Incentives	√		
Additional Park-and-Ride Lots	√	√	√
Increase Bicycle Usage	√	√	√
HOV Designation	√	√	√

Source: Adapted from Puget Sound Recovery Annex, 2011

Sample Temporary Bridge Request Form
Temporary bridge material is kept in locations around the state of Vermont, and policy addresses requirements for emergency use and establishes limits on the duration of use to ensure that the temporary bridges do not become long-term solutions, limiting their availability for future emergencies. Vermont's Request Form for temporary bridge facilities is provided herein.

Framework for Pre-Fabricated Bridge Elements and Systems (PBES) Decision-Making
This is a decision-making tool from FHWA to help answer whether a pre-fabricated bridge is achievable and effective for a specific bridge location for the owner agency and contractor and implementers, including designers and project managers. The tool includes a Flowchart for High-Level Decision on Whether a Pre-fabricated Bridge Should Be Used that summarizes the decision process to determine whether a pre-fabricated bridge is effective for a given location and Matrix Questions for High-Level Decision on Whether a Pre-fabricated Bridge Should Be Used. The decision factors are presented in a series of Yes/No questions in matrix form to assist in determining the effective use of pre-fabrication to achieve rapid and limited-impact onsite construction. Projects with a majority of "Yes" responses would benefit from pre-fabrication. Both flowchart and matrix are included. The online version is available at:
http://www.fhwa.dot.gov/bridge/prefab/framework.cfm

TEMPORARY BRIDGE REQUEST FORM

Existing Bridge Location:

Town_____
Town Highway No. _____
Town Bridge No. _____

1. Is the existing bridge currently closed to all traffic? YES ( ) NO ( )
2. Is the existing bridge currently load restricted? YES ( ) NO ( ) If load restricted, what is the maximum weight the existing bridge can carry?_____tons
3. What is the reason for the existing bridge being closed or load restricted?
   Deterioration? YES ( ) NO ( )
   Damage from flood or other natural event? YES ( ) NO ( )
4. Is the existing bridge associated with a:
   State TH Bridge and Culvert Project? YES ( ) NO ( )
   FEMA Project? YES ( ) NO ( )
   FHWA ER Project? YES ( ) NO ( )
5. Would closure of the existing bridge prevent emergency services from reaching any homes or businesses? YES ( ) NO ( ) If YES:
   How many homes? _____
   How many businesses?_____
6. Would closure of the existing bridge require a detour? YES ( ) NO ( ) If YES:
   Maximum length of detour?_____

Type/Length of Temporary Bridge Requested:

Type: One lane_____ Two lane_____
Span Length: _____feet
Load Capacity: HS20____ HS25_____

Length of Time Temporary Bridge Requested For:
(Maximum deployment time is 48 months)

Length of request:_____months

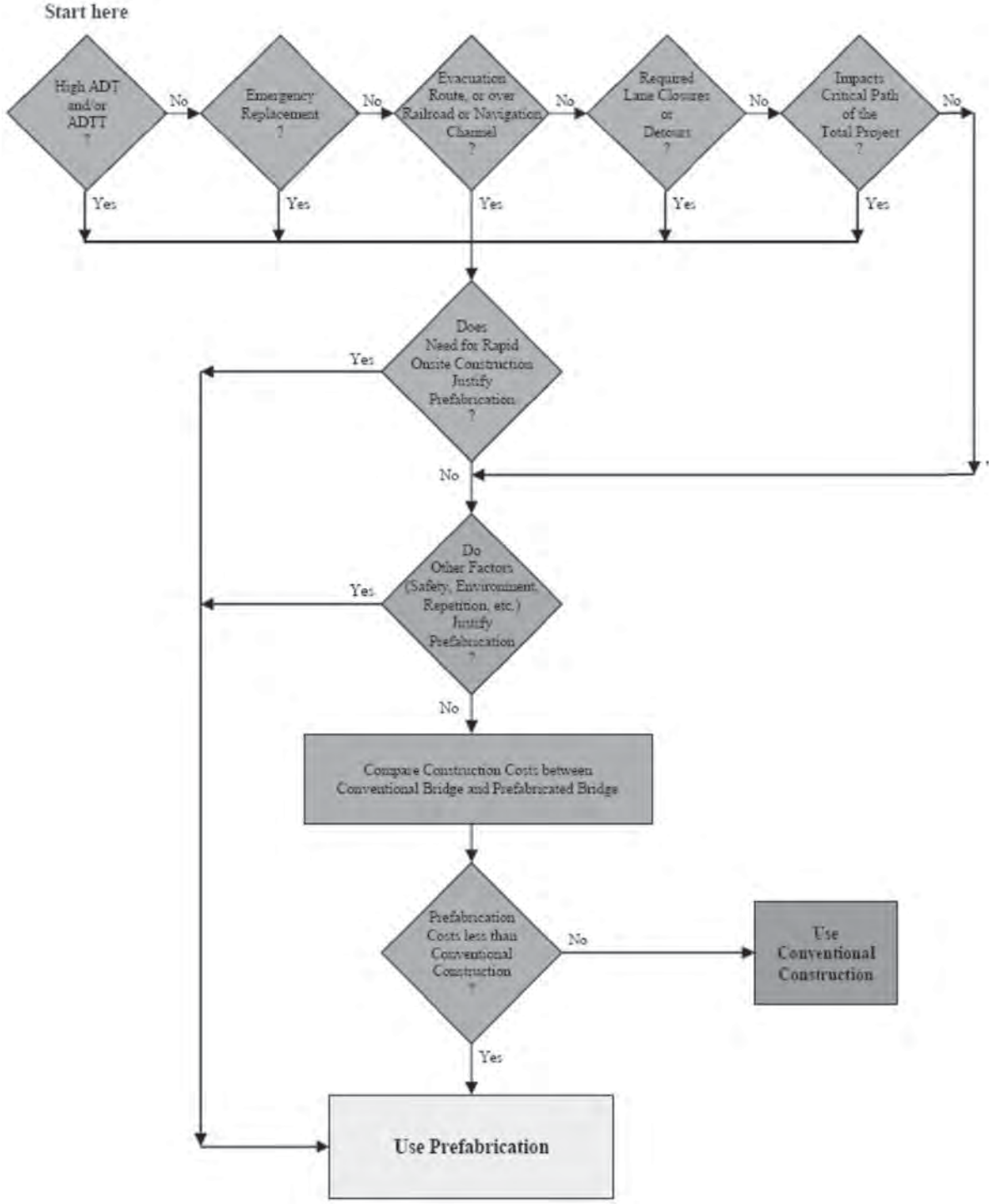
Town's Authorized Representative:_____ _____
Signature Date

District concurrence with request: YES ( ) NO ( )

District Authorized Representative:_____ _____
Signature Date

Source: Vermont Department of Transportation

High-Level Decision Flowchart: Prefabricated Bridge



Source: FHWA Accelerating Technology: Prefabricated Bridge Elements and Systems

Questions for High-Level Decision on Whether Pre-Fabricated Bridge Should Be Used

Questions	Yes	Maybe	No
Does the bridge have high average daily traffic (ADT) or average daily truck traffic (ADTT), or is it over an existing high-traffic-volume highway?			
Is the bridge on an emergency evacuation route or over a railroad or navigable waterway?			
Will the bridge construction impact traffic in terms of requiring lane closures or detours?			
Is rapid recovery from natural/manmade hazards or rapid completion of future planned repair/replacement needed for this bridge?			
Is the bridge location subject to construction time restrictions due to adverse economic impact?			
Do worker safety concerns at the site limit conventional methods, e.g., adjacent power lines or over water?			
Is the site in an environmentally sensitive area requiring minimum disruption (e.g., wetlands, air quality, and noise)?			
Are there natural or endangered species at the bridge site that necessitate short construction time windows or suspension of work for a significant time period, e.g., fish passage or peregrine falcon nesting?			
If the bridge is on or eligible for the National Register of Historic Places, is pre-fabrication feasible for replacement/rehabilitation per the Memorandum of Agreement?			
Can this bridge be designed with multiple similar spans?			
Does the location of the bridge site create problems for delivery of ready-mix concrete?			
Will the traffic control plan change significantly through the course of the project due to development, local expansion, or other projects in the area?			
Are delay-related user costs a concern to the agency?			
Can innovative contracting strategies to achieve accelerated construction be included in the contract documents?			
Can the owner agency provide the necessary staffing to effectively administer the project?			
Can the bridge be grouped with other bridges for economy of scale?			
Will the design be used on a broader scale in a geographic area?			
Totals:			

Source: FHWA Accelerating Technology: Prefabricated Bridge Elements and Systems

Note: One or two of the above factors may warrant the use of pre-fabrication to achieve rapid and limited-impact onsite construction. Alternatively, the user may wish to assign weights to the above questions based on the unique circumstances of the project in order to determine whether pre-fabrication should be used. In any case, pre-fabrication offers advantages for projects with a majority of "Yes" responses.

DEMOLITION: PARTIAL OR COMPLETE

A key to rapid recovery is how quickly the demolition and restoration can begin after the event. Debris removal, both for initial clearing and demolition debris, can be addressed

and planned in advance. An incident involving chemical, biological, or radiological (CBR) agents will result in significant disruption of services. Having a restoration plan vetted in advance and facility personnel trained beforehand substantially reduces the overall time for restoration and recovery.

Guidance and Resources

Debris Removal and Demolition Operations Fact Sheet
Authors: Federal Emergency Management Agency (FEMA)
Date Published: 2007
http://www.fema.gov/public-assistance-local-state-tribal-and-non-profit/recovery-directorate/debris-removal-and

This fact sheet from the FEMA website covers debris removal and demolition operations on both public and private property and the criteria for receiving assistance.

Debris Management Tools

Planning for Natural Disaster Debris
Authors: Environmental Protection Agency (EPA)
Date Published: March 2008
http://www.epa.gov/wastes/conserve/imr/cdm/pubs/pndd.pdf

This EPA document discusses the management of debris from natural disasters, such as hurricanes, earthquakes, tornadoes, volcanoes, floods, wildfires, and winter storms. It includes information on

- Recommended components of a disaster debris management plan.
- Management options for various debris streams that might be found after a natural disaster.
- A collection of case studies that highlights how several communities prepared for and managed debris generated by recent natural disasters.
- Federal, state, and local resources to consult in planning for natural disasters.

FEMA 325 Debris Management Guide
Authors: Federal Emergency Management Agency (FEMA)
Date Published: July 2007
http://www.fema.gov/pdf/government/grant/pa/demagde.pdf

This FEMA guide provides applicants with a programmatic and operational framework for structuring their own debris management plan or ensuring that their existing plan is consistent with FEMA's eligibility criteria. This framework identifies and explains the debris removal eligibility criteria that applicants must meet in order to receive assistance under the FEMA Public Assistance (PA) Program, provides a blueprint for assembling an effective and responsive plan for the entire debris management cycle, and outlines the FEMA PA program debris organizational structure and strategy. It incorporates best practices in debris removal and is tailored to the specific needs of applicants.

Incident Waste Assessment & Tonnage Estimator (I-WASTE)
Authors: Environmental Protection Agency (EPA)
Date Published: March 2008
http://www.epa.gov/nhsrc/news/news051209.html

This tool from EPA supports disposal decisions for waste and debris. I-WASTE provides information on types and volumes of waste materials and potential contaminants generated during an incident; location and contact information for potential treatment/disposal facilities; and health and safety information to ensure public and worker safety during the removal, transport, treatment, and disposal of contaminated waste and debris.

HAZMAT/DECONTAMINATION

An incident involving chemical, biological, or radiological (CBR) agents will result in significant disruption of services. Compared to more common natural disasters, CBR incidents involve unique challenges and require significant operational adjustments. Pre-event planning has been found to be essential. Having a restoration plan vetted in advance and facility personnel trained beforehand substantially reduces the overall time for restoration and recovery.

Checklists, Worksheets, and Toolboxes

Transportation Chemical Spill Checklist
Included herein is a checklist for planning and recovery of a transportation chemical spill, adapted from Madison County North Carolina Emergency Management Hazard Specific Checklists. These checklists are available online at
http://www.madisoncountync.org/eop/Checklists/Checklist_TransportationChemical.pdf

TRANSPORTATION CHEMICAL SPILL CHECK LIST

Planning

- Ensure the public is well informed regarding transportation issues regarding hazardous materials.
- Coordinate with local broadcast media to ensure timely and accurate Emergency Action System activation.
- Coordinate with local plants, businesses or other facilities that receive hazardous materials and obtain information as allowed by Community Right to Know or SARA Title III (Code of Federal Regulations).
- Provide an avenue for transient transportation companies to report chemical spills (i.e., 911).
- Coordinate with Chemtrec (800-424-9300) for timely information regarding spills.
- Coordinate with local transportation departments or state departments of transportation regarding potential for specifying truck routes for hazmat carriers, avoiding densely populated areas.

- Coordinate with schools, daycare centers, hospitals, etc., in proper precautions and emergency actions prior to a transportation chemical spill or accident.
- Obtain transportation information from DMV or other state agencies regarding the number of trucks passing through in a 24-hour time period, thus calculating your risk potential.
- Coordinate and plan at least one exercise (table top or practical) tri-annually.
- Conduct hazard analysis of vital facilities and the impact of a major chemical spill on one or more of those facilities.
- Establish or facilitate joint incident command with agencies likely to respond, such as fire departments, regional hazmat teams, etc.
- Ensure fire department personnel and other responders meet or exceed OSHA 1910.120.
- Determine the location of the nearest hazmat response team and their capability.
- Determine the availability of shelters and obtain shelter agreements if the Red Cross has not.
- Coordinate with Red Cross, public agencies, and/or the Salvation Army for shelter operations.

Recovery

- Gather damage assessment information from damage assessment teams.
- Obtain information from technical sources regarding health effects duration.
- Obtain information from Red Cross regarding number of shelterees and support necessary for continued operation.
- Obtain from Red Cross an estimated duration period for continued shelter operations, if any.
- Obtain information from utilities regarding outages, length of repair, safety, etc.
- Assess citizen/community needs for individual assistance and/or public assistance.
- Activate local unmet-needs committee, if appropriate.
- Gather financial information from the Finance Officer.
- As appropriate, gather additional information to include:
    - Personnel that responded and the time involved in the response.
    - Time sheets or time logs.
    - Supplies used.
    - Contracts issued.
    - Purchase orders issued.
    - Any other expenditures.
    - Damages to buildings, equipment, utilities, etc.
    - Loss of life of any public servant.
    - Documents regarding economic impact.

      Notation: In most cases the person responsible for the chemical leak or spill is responsible for cleanup and all costs associated with response as well. Volunteer resources may not be reimbursable unless under contract.
- Develop or generate reports for the following, as appropriate:
    - FEMA

    - State
    - Local elected officials
    - County/City /Town Managers
    - Others requiring or requesting reports
- Coordinate recovery organizations including federal and state agencies and private or volunteer relief organizations.
- Establish donated goods management based on policy and procedure.
- If a Presidential declaration of disaster is made, file "Request for Public Assistance" to apply for assistance as soon as possible with the proper state or federal agency.
- Ensure public officials are made aware of the assistance application process, if applicable.
- Ensure the general public is made aware, through the public information officer, of the assistance application process, if applicable.
- Perform an incident critique as soon as possible with all possible response organizations.
- Review agency and self-performance.
- Review the weaknesses of the plan.
- Correct weaknesses.
- Implement hazard mitigation or modify hazard mitigation plan accordingly.
- Brief elected officials with updated information and disaster recovery progress.

Source: Adapted from Madison County North Carolina Emergency Management.

Tools and Resources

Compilation of Available Data on Building Decontamination Alternatives Report
Authors: Environmental Protection Agency (EPA)
Date Published: 2005
http://www.epa.gov/nhsrc/pubs/600r05036.pdf

This report, commissioned by the EPA's National Homeland Security Research Center (NHSRC), provides background information regarding potential building decontamination technologies and serves as an educational tool for building decontamination. The guidance document can assist in most effectively selecting and implementing the decontamination approach for a building following a CB (chemical and biological) attack.

Remediating Indoor and Outdoor Environments: EPA Decontamination Reports
Authors: Environmental Protection Agency (EPA)
Date Published: 2005
http://www.epa.gov/nhsrc/aboutdecon.html#overview
Model Recovery Procedure for Response to a Radiological Transportation Incident

EPA's homeland security research on indoor and outdoor decontamination work provides research to assist in detecting contamination and determining its extent, containing contamination to minimize exposure, decontaminating buildings and outdoor areas in a timely and cost-effective manner, and disposing of contaminated materials. The

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effectiveness of existing methodologies for detection and containment, site decontamination, and waste disposal is being assessed by the EPA.

Transportation Emergency Preparedness Program
Authors: Department of Energy
Date Published: 2005
http://www.em.doe.gov/Transportation/TEPP_Home.aspx

The Transportation Emergency Preparedness Program (TEPP) model recovery procedure outline gives an overview of incident response procedures. It contains the recommended elements for developing and conducting recovery planning at a transportation incident scene involving radiological materials. Encompassing responsible parties, location, type of hazard, safety concerns, impact, recovery, etc., the document includes a section on recovery procedures.

Action Plan to Reopen Contaminated Airport
Authors: Lawrence Livermore National Laboratory
Date Published: September 2007
https://www.llnl.gov/str/Dec06/pdfs/12_06.2.pdf

The Department of Homeland Security (DHS) funded a project led by Lawrence Livermore and Sandia National Laboratories to minimize the time a major transportation facility would be closed following a biological attack. Response and restoration protocols for such events are included in the document.

Restoration Plan for Major Airports after a Bioterrorist Attack
Authors: Lawrence Livermore National Laboratory
Date Published: January 2007
https://e-reports-ext.llnl.gov/pdf/342514.pdf

This document provides general guidelines for developing a Restoration Plan for a major airport following release of a biological warfare agent.

Guide to CHEMTREC® for Emergency Responders
Authors: American Chemistry Council, Chemtrec®
Date Published: January 2007
http://www.chemtrec.com/responder/resources/Documents/CHEMTRECGuideforEmergencyResponders[1].pdf

The CHEMTREC® Guide for Emergency Responders (Guide) provides emergency response personnel, law enforcement agencies, and other interested persons with a better understanding of CHEMTREC's services. The Guide includes:

- How CHEMTREC handles emergency incidents, what assistance is provided, and what information will be requested from the caller to assist with chemical emergencies.

- How CHEMTREC can help emergency responders better prepare for emergencies through the drill/exercise program.
- A description of hands-on CHEMTREC training programs and other training sponsored by the American Chemistry Council.

DESIGN

Making design decisions as soon as possible can minimize recovery time. Some decisions can be made before an event, such as what design strategies to take when rebuilding or replacing existing infrastructure.

- Build "as is" or design new structure?
- Can designs be simplified, such as reducing architectural details in temporary structures?
- Should desired or planned infrastructure improvements be incorporated into the designs?

Resources and Tools for Design

Design Guide for Improving Critical Facility Safety from Flooding and High Winds
Authors: Federal Emergency Management Agency (FEMA)
Date Published: January 2007
http://www.fema.gov/library/viewRecord.do?id=2441

This manual concentrates on critical facilities and makes recommendations on the performance of these types of buildings based on the experience of Hurricane Katrina. It provides building professionals and decision makers with information and guidelines for implementing mitigation measures to reduce the vulnerability to damage and disruption of operations during severe flooding and high-wind events.

Design Consideration for Improving Critical Facility Functionality During Flood Events
Authors: Federal Emergency Management Agency (FEMA)
Date Published: October 2009
http://www.fema.gov/library/viewRecord.do?id=3824

This advisory provides recommendations for reducing the effects of flooding on existing critical facilities. It specifically applies to the essential critical facility systems that must remain functional during and after flood events.

The Repair of Earthquake Damaged Concrete and Masonry Wall Buildings (FEMA 308)
Authors: Federal Emergency Management Agency (FEMA)
Date Published: September 2007
http://www.fema.gov/library/viewRecord.do?id=1533

This document provides practical guidance for the repair and upgrade of earthquake-damaged concrete and masonry wall buildings. Target audiences include design engineers, building owners and officials, insurance adjusters, and government agencies.

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The publication contains sections on performance-based repair design, repair technologies, categories of repair, and nonstructural considerations. The last section includes repair guides, which provide outline specifications for typical repair procedures.

CONTRACTING

Major repair or replacement construction typically requires contracting for engineering and contractor services. The following resources and tools can assist in answering the key questions:

- How should a contractor be selected?
- What type of contract should be used?
- How can the contracting and approval process be expedited?

Checklists and Worksheets for Contracting

Project Guidance Matrix for Innovative Contracting Practices
The Project Guidance Matrix is a tool to use as a general guide in selecting projects that may be good candidates for innovative contracting type provisions. The matrix shown herein was adapted from PennDOT Innovative Bidding ToolKit (2011) available online at *ftp://ftp.dot.state.pa.us/public/PubsForms/Publications/Pub%20448.pdf*.

Oregon DOT Design-Build Base Documents
http://www.oregon.gov/ODOT/HWY/MPB/design_build.shtml#Additional_Information
The Oregon DOT Design-Build Program website includes reference documents and flowcharts including the following:

- Design-Build Schedule Template (63-Step Process) (.pdf)
- Decision Matrix for Design-Build Delivery (.pdf)
- Design-Build Procurement Process Flow Chart (63-Step Process) (.pdf)
- Design-Build Low Bid Procurement Process Flow Chart (15-Step Process) (.pdf)
- Quick Guide to Design-Build Delivery (.pdf) Modified 3/01/10
- Schedule Comparison between Delivery Methods (.pdf)

Design-Build Rules, Procedures, and Guidelines
http://www.dot.state.fl.us/construction/designbuild/DBRules/DBRulesMain.shtm
The Florida DOT website includes guidelines, checklists, and other resources to assist in design-build projects including:

- Checklist for FHWA Oversight Record Requirements
- Design-Build Guidelines
- Design-Build Pre-Scoping Questions
- FHWA SEP-14 Approval Letter
- Project Selection Guidelines

Caltrans Design-Build Demonstration Project
http://dot.ca.gov/hq/oppd/designbuild/db.htm

The Caltrans Design-Build Demonstration Program website provides various documents developed to implement design-build.

Performance Contracting Framework
http://www.fhwa.dot.gov/hfl/framework/03.cfm
FHWA developed a performance contracting framework for reconstruction projects that can be used as a reference guide to accelerate the solicitation and development process.

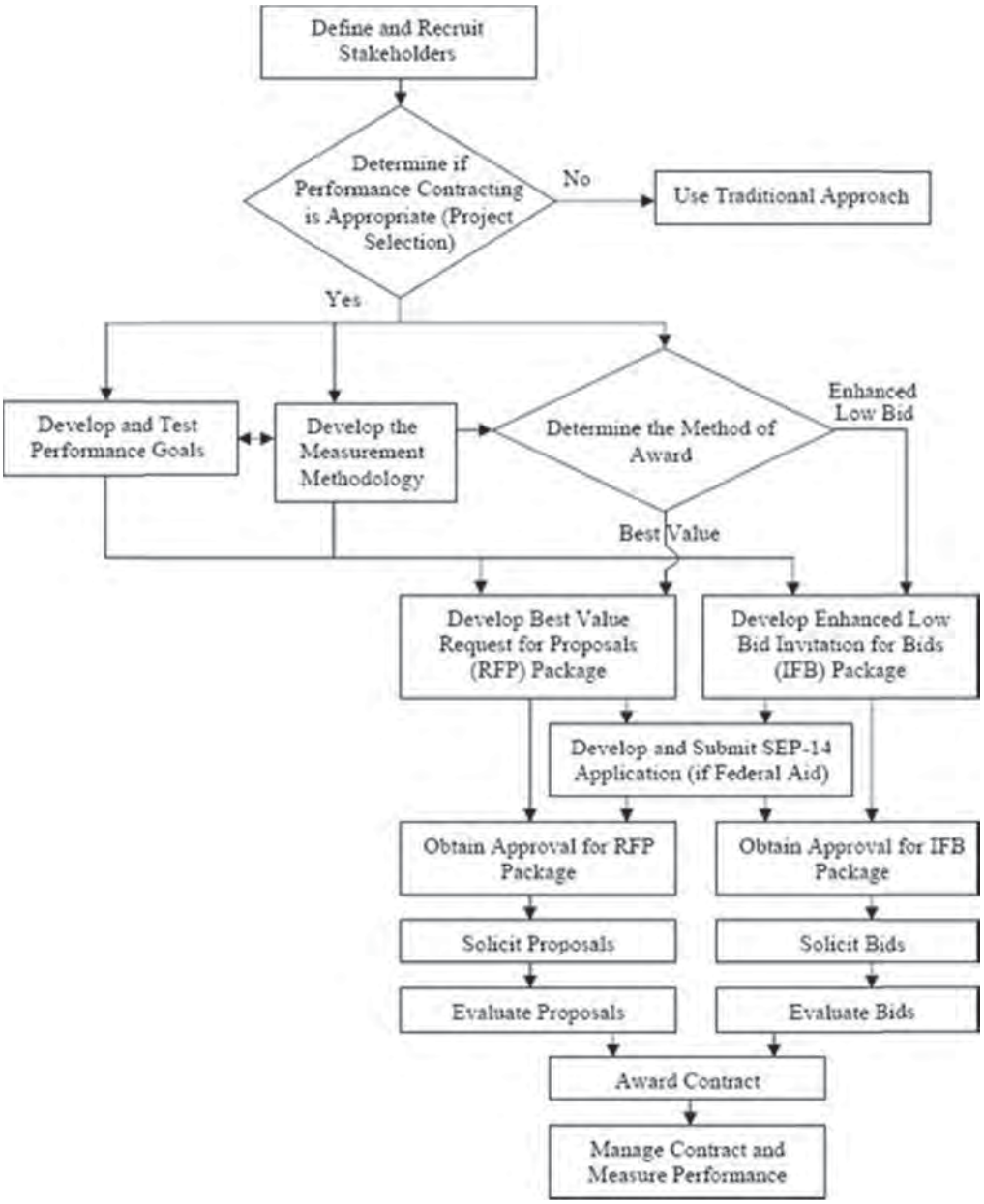
Process for Defining the Contract Performance Goals and Measures
http://www.fhwa.dot.gov/construction/contracts/pcfc_2012/pcfc06.cfm
The basis of any performance contract is the set of performance goals that defines what the contractor is to achieve under the contract. The FHWA provides lessons learned and a goal development process in the flowchart shown herein.

Project Guidance Matrix

Project Criteria	Low Bid Design-Build	Adjusted Bid One Step Design-Build	Adjusted Bid Two Step Design-Build	Incentive/ Disincentive for Early Completion	A+Bx Bidding	Lane Rental	Warranties	Lump Sum
Emergency project	X	X	X	X	X			
Minimize construction time	X			X	X			
Must complete project by a specific date	X			X				
Possible conflict between construction and a major public event				X		X		
Significant construction impact to local businesses				X	X	X		
Lengthy detours/significant delays				X	X	X		
Detours impractical but lane and/or shoulder closures required					X	X		
High traffic volume roads/high road user costs (RUC)				X	X	X		
High RUC and public desire to complete project early				X	X	X		
C factor					X			
Low RUC but need to expedite construction				X	X	X		
Safety issues related to construction				X	X	X		
Multiple bidders anticipated					X			
Low number of bidders anticipated			X	X	X			
Major objective is to reduce total project duration (design & construction)		X	X	X				
Major objective is to reduce design procurement time		X						
Major objective is to guarantee quality of specific items							X	
Well defined project with common work items	X	X						X

Source: Adapted from PennDOT Innovative Bidding ToolKit, 2011.

Goal Development Process Flowchart



Source: FWHA Construction, Performance Contracting for Construction

Guidance and Resources

NCHRP Web Document 38: Quality-Based Performance Rating of Contractors for Prequalification and Bidding Purposes

Authors: Minchen, R. E., and G. R. Smith
Date Published: 2001
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w38.pdf

This report examines the concerns facing owners and contractors with regard to competitive-bid construction projects and whether owners treat low-quality work no differently than high-quality work. The report notes that the concerns are shared by U.S. DOT officials and the state highway agencies that compose the American Association of State Highway and Transportation Officials (AASHTO) who requested that NCHRP manage research to develop a Quality-Based Performance Rating (QBPR) system. The purpose of this study was to develop a comprehensive quality-based rating system that will be effective in prequalification systems and bid evaluation. The result of this study is a rating system to help determine qualification for construction contract awards.

AASHTO Guide for Design-Build Procurement

Authors: AASHTO
Date Published: 2008
https://bookstore.transportation.org/Item_details.aspx?id=1180

This AASHTO guide is intended to supply state highway agencies with strategies and methods for successful design-build implementation, including the preparation of requests for qualifications (RFQ) and requests for proposals (RFP) and the selection of a qualified proposer. It is based on best practices from experienced state highway agencies and other public-sector agencies. Topics include understanding design-build, developing a design-build program, defining project goals, and allocating project risks. Over 50 contractual provision examples are provided.

Primer on Contracting for the Twenty-first Century, Fifth Edition 2006, A Report of the Contract Administration Section of the AASHTO Subcommittee on Construction

Authors: AASHTO
Date Published: 2006
http://construction.transportation.org/Documents/PrimeronContracting2006.pdf

The 2006 Primer on Construction Contracting for the 21st Century is an updated version of the “1997 Primer on Contracting 2000.” It is intended to provide summary information on non-traditional contracting techniques. The Primer provides a description of the contracting technique, information regarding the use of these provisions, a list of contracting agencies that have experience with the technique, and a contact for additional information.

Contract Administration Core Curriculum Participant's Manual and Reference Guide
Authors: Federal Highway Administration (FHWA)
Date Published: 2010
http://www.fhwa.dot.gov/programadmin/contracts/coretoc.cfm

This course has been prepared by the FHWA Contract Administration Group and is designed to discuss contract provisions, administrative procedures, and applicable policies related to federal-aid design and construction contracts. An extensive appendix is provided, and participant expectations upon completion of the course are noted.

Alternative Project Delivery Procurement and Contracting Methods for Highways
Authors: Keith R. Molenaar (editor) and Gerald Yakowenko, P.E., (Editor) American Society of Civil Engineers (ASCE)
Date Published: 2007
http://cedb.asce.org/cgi/WWWdisplay.cgi?156076

This book provides a comprehensive and objective presentation of methods for improving the efficiency and effectiveness of project delivery and contracting. It provides information on design-build, construction management at risk, performance-based road maintenance contracts, best-value procurement, quality-based contractor qualification, warranty contracting, and incentive/disincentive contracting.

Innovative Procurement Methods
Authors: Trauner Consulting Services for California Department of Transportation
Date Published: 2007
http://www.dot.ca.gov/hq/oppd/contracting/InnovativeProcurementPractices.pdf

This report evaluates selected innovative contracting strategies that include description, objective, summary of past and ongoing DOT experience, and project-selection criteria. A qualitative assessment of the advantages and disadvantages of each particular method is also provided. To provide a baseline for comparison, an evaluation of the advantages and disadvantages of the traditional design-bid-build approach has been prepared as well.

Innovative Contracting Practices
Authors: Minnesota Department of Transportation (MnDot)
http://www.dot.state.mn.us/const/tools/innovativecontract.html

This report is a web-based resource providing detailed information about MnDOT initiatives and techniques for reducing construction time and delivery of projects, improving quality and developing new processes to administer projects. Eight sections are presented, and each gives an overview of methods related to the overall improvement strategies. Subsections and links are included with an overview of guidelines and goals, as well as resources, awards, and contacts.

NCHRP Report 561: Best-Value Procurement Methods for Highway Construction Projects
Authors: Scott, III, S.; K. R. Molenarr; D. D. Gransberg; and N. C. Smith
Date Published: 2006
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_561.pdf

This NCHRP report provides detailed information on the procedures and algorithms used by various contracting agencies to determine best value. Screening criteria for selecting projects for application of best-value procurement, implementation strategies, and a model best-value specification were also developed.

Guidebook for Design-Build Highway Project Development
Authors: Washington State Department of Transportation (WSDOT)
Date: June 2004
http://www.wsdot.wa.gov/NR/rdonlyres/46196EB8-F9D0-4290-8F55-68786B1DA556/0/DesignBuild_GuidebookJun2004.pdf

This guidebook provides a framework for using the design-build contracting technique. Commonly asked questions are presented and answered in the context of WSDOT's traditional design-bid-build process versus design-build contracting procedures. This guidebook has been prepared primarily for the Program Manager and Project Engineer who are in responsible roles to appropriately select, develop, and administer a project using design-build contracting. The guidebook also may be useful to Project Team members who will also be involved in the process.

Incentive/Disincentive (I/D) for Early Completion
Authors: Federal Highway Administration (FHWA)
Date Published: 1989
http://www.fhwa.dot.gov/construction/contracts/t508010.cfm

This technical advisory provides guidance for the development and administration of incentive/disincentive (I/D) provisions for early completion on highway construction projects or designated phase(s). Its use is primarily intended for those critical projects where traffic inconvenience and delays are to be held to a minimum. The scope of this advisory covers definitions, background and guidance, project selection and development, determinations of I/D amounts and time, contract administration, and road user cost in low-bid determination.

NCHRP Synthesis 379: Selection and Evaluation of Alternative Contracting Methods to Accelerate Project Completion
Authors: Anderson, S. D., and I. Damnjanovic
Date Published: 2009
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_379.pdf

This study explores the process for selection of alternative contracting methods (ACMs) that can potentially accelerate project completion. The goal of this study was to

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summarize the state of practice in selecting ACMs. The report also examines factors associated with selecting one type of alternative contracting technique over another and the concerns of state transportation agencies with regard to implementation, effectiveness, and impact.

Special Experimental Project No. 14—Innovative Contracting
Authors: Federal Highway Administration (FHWA)
Date Updated: April 2011
http://www.fhwa.dot.gov/construction/cqit/sep14.cfm

This Construction Program Guide presents the legal basis for allowing state DOTs to evaluate non-traditional contracting techniques with regard to FHWA's Special Experimental Project No. 14 (SEP-14) - "Innovative Contracting." Separated into three general categories, the information provided covers laws, regulations, orders, and policy, as well as guidance and training.

CONSTRUCTION

A number of construction strategies can expedite recovery by minimizing disruption and reducing project delivery time. These strategies include using the design-build process, planning for staged or phased construction, and utilizing accelerated work schedules. The resources and tools that follow can assist in answering these key construction questions:

- What construction strategies are available for recovery? What construction strategies can be used to accelerate construction?
- What construction techniques are available to expedite recovery?
- What can be done in advance to prepare for recovery construction?

Checklists, Worksheet, and Toolboxes

Construction Pre-Scoping Questions
Pre-scoping questions have been developed by Florida DOT to assist in developing project-specific Design and Construction Criteria Packages. While many of the issues raised by the pre-scoping questions may not apply to all projects, this document can serve as a guide in scoping the necessary site surveys and in defining project constraints. Categories of questions include environmental, geotechnical, and structural questions for bridges, structures, and roadways. The document can be found online at *http://www.dot.state.fl.us/construction/designbuild/DBRules/DB_PRESCOPING_QUESTIONS.docx*

Design-Build (D/B) Pre-scoping Questions

Environment-Related Surveys/Permit Coordination	Do any of the existing steel bridge coatings within the project limits contain lead based paint? Bridges of concern include bridges to be painted, rehabilitated, widened, or removed. Are there sea grasses within or in the vicinity of the project limits (for water projects)? What are the mitigation ratios? Are there turbidity/jetting restrictions? Is there dredging? Are temporary work platforms required to facilitate crane access in shallow water? What are the specific permit requirements? Are there jurisdictional wetlands within the project limits? What are the impacts? How will impacts be minimized? How will impacts be mitigated? What are the specific permit requirements? Are there contaminated sites within the project limits? Will D/B Team be expected to coordinate with district-wide specialty contractor? Will location and type of contamination dictate roadway alignments, retention pond placement, or structure versus retaining walls? Address items such as special handling and disposal requirements of drilled shaft or other excavated materials. For bridges crossing navigable waterways, have the minimum vertical and horizontal clearances been coordinated with the permitting agencies? For bascule bridges, provide clearances for both the open and closed positions. Are fenders and navigational lighting required? If project includes removal of existing structure near a navigational channel, is additional removal below the mud line required to facilitate long-term maintenance dredging? This is especially a concern when existing mud-line bascule piers are to be removed due to the costs involved. What are the specific permit requirements? Are there local ordinances related to noise? What are the specific permit requirements? Are there endangered species potentially impacted by the project? How will impacts be minimized? What are the specific permit requirements? Are there any blasting restrictions? Are there environmental restrictions concerning whether bridge drainage can discharge directly into the waterway? What are the specific permit requirements related to bridge drainage?
Geotechnical-Related Questions	Should a maximum wall height or fill height be specified for the project? Should maximum begin bridge stations and minimum end bridge stations be given? Are there specific areas where contaminated soils exist? Have the contaminants been identified? Are there special requirements? Will any of these areas need to be bridged to prevent them from being disturbed?

	What is the location and minimum number of static or statnamic load tests, based on project site variability required to justify increasing the design resistance factor for both piles and drilled shafts. Should partial height walls such as toe walls or perched walls be allowed? Are there adjacent properties that may be subject to damage during construction due to excessive vibration? Examples may include laser-surgery-related businesses, railroad facilities, and historic buildings located close to potential super-pave, pile driving, drilled shaft casing installation, blasting or sheet piling installations. Provide additional vibration requirements in the RFP beyond what is already covered under Specification 455-1.1, as necessary. Is the site prone to soil set-up? Should pile bearing resistance acceptance criteria be developed in the RFP that allow for some soil set-up without requiring every pile to be set-checked?
Structural-Aesthetics-Related Questions	Is each bridge superstructure to be constructed of the same material, i.e., all pre-stressed beams, or all structural steel? Will steel spans be allowed in combination with concrete spans? Should the steel be painted the same color as the concrete? Should the structure depth of the fascia girders for all bridges be held constant without steps? Are there exceptions? For aesthetic reasons, will some of the 3rd and 4th level structures within an interchange be required to be box girders? Are there other bridges within the project requiring specific structure types? Are there specific aesthetic requirements for the bridges and/or walls? Depending on flexibility of the project based on public commitments, provide sketches that outline rigid requirements or give general level of aesthetic and guidelines to allow flexibility. Sketches should cover anticipated pier types and shapes for the project. Are all new and existing concrete surfaces to be coated with Class 5 Applied Finish Coating? Include requirements for walls, bridges, and sound barriers as required. Are there exiting steel bridges on the project that require painting? Include coating and color requirements. Is weathering steel required? Should exterior girders require painting for aesthetic considerations? Should all bridge drainage piping be hidden from view? Should retaining walls/bulkheads have a concrete facing? Should all bulkhead walls have a concrete cap? Are exposed steel walls allowed? Is an anti-graffiti coating required? Coordinate with District Maintenance Office to see whether to specify a sacrificial or permanent coating system. Specify limits.

	Are utility attachments required on the bridge? Include requirements and specify whether utilities are to be hidden from view.
Structural-Related Questions	Is the wind velocity defined appropriate or should a higher wind velocity be required? If higher velocity is appropriate provide a requirement in the RFP.
	For bridges near airports, will construction be affected by temporary glide path ceiling restrictions? Will any permanent structures, such as high mast lighting, be prohibited due to permanent glide path ceiling restrictions? Define restrictions and include all airport, local government, and FAA coordination requirements in the RFP. Does bridge cross a navigational waterway? Based on pass point survey data, develop ship impact load versus distance from navigable channel in RFP. Alternatively, set input parameters for site, i.e., importance factor, water velocities, etc., and allow each D/B Team to modify pier spacing to determine pier strength requirements within these fixed parameters. Does bridge cross a large body of water near the coast? Set low member elevation or strength requirements based on wave vulnerability analysis performed by a Coastal Engineer prior to finalizing the RFP. Also address wall and shore protection requirements. Does project include replacing or rehabilitating an existing bascule bridge where traffic is to be maintained on existing structure during construction? Include all bascule bridge maintenance and operation requirements in the RFP. Are there special inspection access requirements, such as maximum bridge width or spacing between parallel bridges, associated with accommodating snooper access? Does the project include TL-5 or TL-6 traffic railing barrier requirements? Specify limits. Does the project include bridges to be widened? Verify that all bridges to be widened have been load rated in accordance with the Structures Manual prior to finalizing the RFP. Acquire and include all necessary exceptions and variances related to design capacity of existing bridges to remain. Should bridge widenings match existing superstructure types (in-kind or similar)? Should bridge widenings match existing substructure (in-kind or similar)? Does the project have minor bridge widenings that require seismic provisions? For existing bridges to be widened, are any maintenance repairs or strengthening required based on bridge inspection reports? Are there bridge widenings with existing modular joints that are no longer available? For each new bridge and each bridge widening, provide environmental classification.

	Is there a minor bridge widening spanning a navigable waterway that requires Vessel Collision design? Unusual structures located in marine environments may require concrete admixtures and/or other measures to enhance durability. Is corrosion of structural bolts likely to be a prominent maintenance issue to consider? Check with the district maintenance engineer to see if this is a problem Is the maximum grade of all bridge sidewalks required to be 5% or less? Are there bridges considered critical to the survival of major communities or to the security and defense of the United States? For new bridges to be constructed alongside an existing bridge to remain, should the new substructure components be aligned with the existing substructure components? If bottom of footing elevations are set a minimum of 1 foot below MLW, will tides consistently expose piles for extended periods? If so, specify a lower maximum footing elevation to eliminate exposure of piles. If the D/B Team chooses to use submerged footings, should a minimum clearance between MLW or NLW and the top of the footing be specified based on the type of boat traffic using the waterway? Steel structures located in very harsh marine environments may require a special coating system to enhance durability. For steel structures located in a harsh marine environment, consideration should be given to requiring box girders over I-girders to enhance durability. Are open expansion joints allowed? Is a TL5 or TL6 barrier required within the limits of the project? Are there existing sign attachments to traffic railings within the limits of the project? If so, specify that the signs be relocated and which are to remain. Are there existing bridges to be widened that have asphalt overlays? Was the overlay thickness part of the original design? Are there skewed bridges to be widened with FIBs? If so, specify restrictions as necessary on skewed beam ends, skewed bearing pads, and end diaphragms.
Roadway-Related Questions	Have all approved design exceptions and variations been included? Have all approved typical sections been included? Have all ultimate typical sections been included, when applicable. Have all required traffic movements been defined, including number of lanes? Has the ultimate master plan been included, when applicable?

	If a concept master plan is included, will an alternative plan be allowed if the D/B Team provides a traffic analysis showing that the level of service, operational capacity, and safety are equal to or better than the concept? Include a traffic model and toll and revenue study, if applicable. Identify primary movements. Have all existing utility owners been identified? Have all adjacent projects been identified? Have all project-specific traffic control restrictions been identified? These may include traffic restrictions during special events, detour limitations, etc. Include all horizontal and vertical clearance requirements in the RFP for all crossing roadways, railroad tracks, etc. Include any additional requirements related to accommodating the ultimate section or ultimate corridor master plan. Are there critical project milestones that should be listed in D/B Team's schedule?

Source: Florida DOT Design-Build, Design and Construction Criteria.

Resources and Tools for Construction

Current Design-Build Practices in Transportation Projects

Authors: Design User's Group, Federal Highway Administration (FHWA)
Date Published: 2009
http://www.fhwa.dot.gov/construction/contracts/pubs/dbpractice/dbpractice.pdf

This NCHRP report provides detailed information on the procedures and algorithms used by various contracting agencies to determine best value. Screening criteria for selecting projects for application of best-value procurement, implementation strategies, and a model best-value specification were also developed.

NCHRP Report 561: Best-Value Procurement Methods for Highway Construction Projects

Authors: Scott, III, S.; K. R. Molenarr; D. D. Gransberg; and N. C. Smith
Date Published: 2006
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_561.pdf

This NCHRP Report provides detailed information on the procedures and algorithms used by various contracting agencies to determine best-value. Screening criteria for selecting projects for application of best-value procurement, implementation strategies, and a model best-value specification were also developed.

Accelerated Bridge Construction Technologies

Authors: Federal Highway Administration (FHWA)
Date Published: 2009
http://www.fhwa.dot.gov/bridge/accelerated/index.cfm

This portion of the FHWA website contains reports and presentations including bridge construction cost studies, bridge lifting, bridge removal, and technology innovations. Links are also provided to a session conference on bridge engineering, a workshop on bridge elements and systems, outcomes from a 2007 conference on seismic accelerated bridge construction, and the 2008 FHWA accelerated bridge construction conference, "Highway for Life."

Rapid Bridge Replacement: Processes, Techniques and Needs for Improvement
Authors: Yong Bai, Ph.D., M.ASCE, and William R. Burkett, A.M.ASCE, Journal Of Construction Engineering And Management
Date Published: November 2006
http://www.iri.ku.edu/publications/JCEM_Nov06.pdf

This report outlines research results from a project designed to identify rapid bridge replacement processes, techniques, and needs for improvements. The focus was on various guides mandated after 9/11 and sponsored by AASHTO. The study covered three cases of previous bridge replacements following extreme events and allowed the research team to study the outcomes and expand on lessons learned. The research team also identified needed improvements so that the research community at large could investigate new technologies to advance current practices.

Technical Manual for Design and Construction of Road Tunnels, Chapter 16—Tunnel Rehabilitation
Authors: Federal Highway Administration (FHWA)
Date Published: 2009
http://www.fhwa.dot.gov/bridge/tunnel/pubs/nhi09010/16.cfm

This chapter of the Technical Manual for Design and Construction of Road Tunnels focuses on the identification, characterization, and repair of typical structural defects in a road tunnel system. Various repair methods are included, such as methods for demolition of unsound concrete, brick, or steel; methods for the restoration of the tunnel liner; and details for the repair of concrete, steel reinforcement, and embedded elements of the tunnel liner system.

Construction Projects Incorporating Experimental Features
Authors: Federal Highway Administration (FHWA)
http://www.fhwa.dot.gov/programadmin/contracts/expermnt.cfm

This section of the FHWA website is formatted as a series of questions about the Experimental Features program. The purpose of the program is to encourage highway agencies to evaluate new or innovative highway technology, or alternative standard technology, under actual construction and operating conditions by means of a program or experimental construction projects. The questions highlight the key components of the program, including definitions, principles, finances, and results.

Construction Techniques: Bridges

Tools/Resources	
Accelerated Bridge Construction Technologies	This portion of the Federal Highway Administration's website contains reports and presentations including bridge construction cost studies, bridge lifting, bridge removal, and technology innovations. Links are also provided to a session conference on bridge engineering, a workshop on bridge elements and systems, outcomes from a 2007 conference on seismic accelerated bridge construction, and the 2008 FHWA accelerated bridge construction conference, "Highway for Life." *http://www.fhwa.dot.gov/bridge/accelerated/index.cfm*
Rapid Bridge Replacement: Processes, Techniques and Needs for Improvement	This report outlines research results from a project designed to identify rapid bridge replacement processes, techniques, and needs for improvement. The focus was on various guides mandated after 9/11 and sponsored by AASHTO. The study covered three cases of previous bridge replacements following extreme events and allowed the research team to study the outcomes and expand on lessons learned. The research team also identified needed improvements so that the research community at large could investigate new technologies to advance current practices. *http://www.iri.ku.edu/publications/JCEM_Nov06.pdf*
Processes and Techniques for Rapid Bridge Replacement After Extreme Events	Results of pooled-fund research project to identify rapid bridge replacement processes and techniques after extreme events. These events include manufactured and natural disasters such as earthquakes, explosions, fires, floods, and hurricanes. The major players involved in the process, the major tasks to be accomplished, and the major decisions have been identified in the model. *http://www.iri.ku.edu/publications/BaiandKim.pdf*
Post-Earthquake Assessment and Emergency Repair of Bridges	This chapter—from an unpublished draft produced by the Multidisciplinary Center for Earthquake Engineering Research (MCEER), University at Buffalo, for U.S. DOT's Federal Highway Administration as part of Project 106—provides unified guidelines and procedures for conducting pre-event planning for post-event assessment and repair of highway bridges. Although it is not possible to set up procedures that will be applicable to every situation, major issues and needs are addressed. Steps are outlined that can be modified to suit specific cases. *ftp://mceer.buffalo.edu/OConnor/ftp/photos%20of%20bridge%20damage%20from%20earthquakes/Chapter-14-with-figures%20w%20header.doc*

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CONSTRUCTION TECHNIQUES: BUILDINGS

Tools/Resources	
Resources for Commercial Builders for Disaster Recovery	This Department of Energy web link contains brief descriptions and links for commercial builders to learn more about national and regional resources, disaster preparedness, flood and mold cleanup, tools and training, and building design. These resources support the application of energy-efficient, cost-effective, and durable rebuilding strategies. There are also links to resources for state and local officials as well as consumers. *http://www1.eere.energy.gov/buildings/disaster_recovery/dr_commercial.html*
Repair of Earthquake Damaged Concrete and Masonry Wall Buildings (FEMA 308)	This document provides practical guidance for the repair and upgrade of earthquake-damaged concrete and masonry wall buildings. Target audiences include design engineers, building owners and officials, insurance adjusters, and government agencies. The publication contains sections on performance-based repair design, repair technologies, categories of repair, and nonstructural considerations. The last section includes repair guides that provide outline specifications for typical repair procedures. *http://www.fema.gov/library/viewRecord.do?id=1533*
General Guidelines for the Assessment and Repair of Earthquake Damage in Residential Woodframe Buildings	The Consortium of Universities for Research in Earthquake Engineering (CUREE) is conducting ongoing development of Guidelines for Earthquake Damage Assessment and Repair. Other CUREE research reports include EDA-03 - Cyclic Behavior and Repair of Stucco and Gypsum Sheathed Woodframe Walls Phase I and EDA-07 - Cyclic Behavior and Repair of Stucco and Gypsum Sheathed Woodframe Walls Phase II. *http://www.curee.org/zc/index.php?main_page=product_info&products_id=98*
Treatment of Flood Damaged Older and Historic Buildings	The National Trust for Historic Preservation has prepared this booklet to help owners of historic and older buildings minimize structural and cosmetic flood damage. It contains general advice written to cover a wide variety of buildings with varying degrees of flood damage. Guidance for specific tasks after a flood is included as well as diagrams, resources, and information on mold removal. *http://www.preservationnation.org/resources/technical-assistance/flood-recovery/additional-resources/flood-book/Flood-Damage.pdf*
Responding to Floods	The National Trust for Historic Preservation provides extensive information for flood victims in the Disaster Recovery section of their website. The web content is designed to help communities and property owners face the unique challenges brought by floods, provide resources for recovering from floods, and help prepare for future occurrences. Resources, articles, and case studies are included, with critical resources noted by a check mark. *http://www.preservationnation.org/resources/technical-assistance/disaster-recovery/flood-response.html*
Design Consideration for Improving Critical Facility Functionality During Flood Event	This advisory provides recommendations for reducing the effects of flooding on existing critical facilities. It specifically applies to the essential critical facility systems that must remain functional during and after flood events. *http://www.fema.gov/library/file;jsessionid=06EAA8BE123F57FEB2FD46BD833EFBD4.WorkerLibrary? ema*

CONSTRUCTION TECHNIQUES: HIGHWAYS

Tools/Resources	
CA4PRS (Construction Alternatives for Pavement Rehabilitation Strategies)	CA4PRS is a productivity estimation tool developed to aid in evaluating and choosing between highway pavement construction alternatives. *http://www.dot.ca.gov/newtech/roadway/ca4prs/index.htm*
Rapid Pavement Construction Tools, Materials and Methods	To address the need to deliver cost-effective projects while minimizing traffic impacts, the Washington State Department of Transportation (WSDOT) desires to improve their knowledge, awareness, and retention of rapid pavement construction tools, materials, and methods. This project discusses the implementation, use, and experience of using the following items related to rapid pavement construction: CA4PRS (Construction Alternatives for Pavement Rehabilitation Strategies), Portland cement concrete (PCC) pavement panel replacement, polymer concrete and traffic closure windows. CA4PRS is a Microsoft-Access-based software program for predicting construction productivity for highway rehabilitation/reconstruction. Panel replacement techniques and polymer concrete construction are reviewed in an effort to document past successes and failures as well as key decision points when making future project decisions. Finally, a review of traffic closure windows for rapid construction is presented. *http://www.wsdot.wa.gov/research/reports/fullreports/670.1.pdf*
Precast Concrete Pavement Systems for Rapid Pavement Repair and Replacement	Precast concrete pavement systems (PCPS) are especially useful for the rapid repair and replacement of concrete pavement. PCPS (including pre- and post-tensioned slab systems) are pre-engineered concrete pavements that are fabricated off-site and are transported to the project site for installation on a prepared foundation. Developed by AASHTO TIG on Precast Concrete Paving System, June 2006 *http://www.transportation.org/sites/aashtotig/docs/PCPS%20Info%20and%20Commentary%20Document%20-rev%206-4-08.doc*
Precast Concrete Panel Systems for Full-Depth Pavement Repairs: Field Trials	The use of precast slabs as an alternative to conventional cast-in-place repairs may be an effective means of reducing construction time, thereby minimizing user delay and travel costs while obtaining a long-lasting, durable repair. This report summarizes the 3-year study, "Field Trials of Concrete Pavement Product and Process Technology—Precast Concrete System for Rapid Repairs," in which precast slabs were used for joint repair and slab replacement on in-service Michigan and Colorado highways. The report contains a summary of the relevant literature; summaries of the field trials and their findings regarding efficiency and durability; recommendations for precast panel installation; a sample distress documentation report; a presentation of construction guidelines; and a sample special provision specification developed as part of the study. *http://www.fhwa.dot.gov/pavement/concrete/pubs/hif07019/07019.pdf*
Research Into Rapid Road Repair Machine	This project researched rapid road repair best practices, analyzed damage scenarios, developed analytical methodologies, and recommends development of a Rapid Road Repair machine. *http://ahmct.ucdavis.edu/pdf/UCD-ARR-03-12-31-01.pdf*
Strategic Work Zone Analysis Tools	This web resource looks at the FHWA's initiative to improve delays and costs associated with highway work zones. Strategic Work Zone Analysis Tools or SWAT encompasses four tools that are being developed as part of the project, including an Expert System software program, a traffic impact analysis spreadsheet, a cost/alternative analysis spreadsheet, and a detailed simulation model. *http://www.tfhrc.gov/its/swat.htm*

PROJECT MANAGEMENT AND DELIVERY

Project management and delivery describes the relationships and contractual obligations among the owner, designer, and contractor for a construction project. The project delivery process may include planning, budgeting, environmental analysis, design, and construction. There are a number of project management/delivery approaches, which can be grouped into three types: Design-Bid-Build (DBB), Design-Build (DB), and Construction Manager/General Contractor (CM/GC) or Construction Manager-at-Risk (CM-at-Risk). The tools and resources can assist in answering the following key questions:

- What types of project management are available?
- How to determine which type of project management approach to use?
- What can be done before an event to prepare to project management selection?

Checklists, Worksheet, and Toolboxes

Shortening Project Delivery Toolkit
http://www.fhwa.dot.gov/everydaycounts/projects/toolkit

This online toolkit from FHWA presents approaches to improve project delivery times in what the FHWA has identified as frequently cited problem areas such as planning and environmental linkages, clarifying the scope of preliminary design, flexibilities in utility accommodation and relocation and flexibilities in right-of-way. Recommendations, resources, and FAQs are included in the toolkit.

Project Delivery Acceleration Toolbox
http://www.dot.ca.gov/hq/oppd/projaccel/index.htm
The Project Delivery Acceleration Toolbox from Caltrans provides information on efforts (past and present) to accelerate the delivery of transportation projects.

Innovative Project Oversight Practices
http://www.fta.dot.gov/region2_4154.html

This web resource from the FTA describes innovative approaches to project development, project oversight, and environmental management oversight developed by the Lower Manhattan Recovery Office (LMRO) to facilitate the urgency of rebuilding after 9/11. The site includes a Memorandum of Understanding (MOU) to coordinate and accelerate the review of projects under the National Environmental Policy Act (NEPA) in order to develop environmentally responsible projects while preventing project delay, as well as the LMRO Environmental Analysis Framework. The Framework consists of the following components:

- Green Design, Green Construction, and Sustainability Principles;
- Construction Environmental Protection Plan;

- Public Involvement and Governmental Entities Coordination Plan; and
- Baseline Assessment of Resources and Coordinated Cumulative Effects Analysis Approach.

Resources and Tools

Alternative Project Delivery Procurement, and Contracting Methods for Highways
Authors: Keith R. Molenaar (editor) and Gerald Yakowenko, P.E., (Editor), American Society of Civil Engineers (ASCE)
Date Published: 2007
http://cedb.asce.org/cgi/WWWdisplay.cgi?156076

This book provides a comprehensive and objective presentation of methods for improving the efficiency and effectiveness of project delivery and contracting. It provides information on design-build, construction management at risk, performance-based road maintenance contracts, best-value procurement, quality-based contractor qualification, warranty contracting, and incentive/disincentive contracting.

NCHRP Synthesis 402: Construction Manager-at-Risk Project Delivery for Highway Programs
Authors: Gransberg D., and J. Shane
Date Published: 2010
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_402.pdf

NCHRP Synthesis 402 explores current methods in which state departments of transportation and other public engineering agencies are applying construction manager-at-risk (CMR) project delivery to their construction projects.

Design-Build Effectiveness Study
Authors: Federal Highway Administration (FHWA)
Date Published: 2006
http://www.fhwa.dot.gov/reports/designbuild/designbuild.htm

This study examines the effectiveness of the Design-Build (DB) project delivery strategy, while maintaining or improving project quality. The report includes a diagram of DB projects by state, an impact summary, project delivery impact, and contract agency satisfaction.

Current Design-Build Practices in Transportation Projects
Authors: Design User's Group, Federal Highway Administration (FHWA)
Date Published: 2009
http://www.fhwa.dot.gov/construction/contracts/pubs/dbpractice/dbpractice.pdf

This report is a compilation of the design-build experiences of state DOTs and other public agencies responsible for transportation infrastructure. This document provides

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information about the design-build project delivery method and a collection of design-build procurement and contracting practices.

Environmental Compliance and Management

Checklist, Worksheets, and Toolkits

Programmatic Agreement Toolkit
http://environment.transportation.org/documents/programmatic_agreement_toolkit/index.html
To assist state DOTs in their environmental streamlining, the AASHTO Center for Environmental Excellence created this toolkit on developing programmatic agreements. Programmatic agreements (PAs) are important components of any environmental streamlining effort.

Planning and Environment Linkages Tools
http://www.environment.fhwa.dot.gov/integ/edctools.asp
Planning and Environment Linkages (PEL) has been identified by FHWA as one of 10 initiatives included in the Shortening Project Delivery toolkit. The Every Day Counts (EDC)/PEL initiative focuses on the part of PEL that encourages the use of information developed in planning to inform the NEPA process. This can lead to less duplication of effort and more informed project-level decisions. The tools include guidance, a planning questionnaire, and online resources.

Guidance and Resources

Implementing the National Environmental Policy Act (NEPA) for Disaster Response, Recovery, and Mitigation Projects
Authors: Congressional Research Service (CRS)
Date Published: January 2011
http://www.fas.org/sgp/crs/misc/RL34650.pdf
For many federal actions undertaken in response to emergencies or major disasters, NEPA's environmental review requirements are exempted under provisions of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (the Stafford Act). This CRS report discusses NEPA as it applies to projects for which federal funding to recover from or prepare for a disaster has been requested by local, tribal, or state grant applicants. The report provides an overview of the NEPA process, identifies the types of projects (categorized by federal funding source) likely to require environmental review, and delineates the types of projects for which no or minimal environmental review is required and those likely to require more in-depth review.

AASHTO Center for Environmental Excellence
Authors: Congressional Research Service
Date Updated: 2012
http://environment.transportation.org/

AASHTO's Center for Environmental Excellence (Center), developed in cooperation with the FHWA, offers a wide range of products and services to assist transportation agencies in achieving environmental excellence in delivering their transportation programs and projects. Through its information exchange, technical assistance, and partnership-building and training resources, the Center helps transportation agencies incorporate environmental compliance, sustainability, and stewardship into transportation planning, project development, construction, maintenance, and operations. Practitioner's handbooks and webinars are available.

Environmental Analysis and Review
Authors: Federal Transit Administration
Date Updated: 2012
http://fta.dot.gov/planning/planning_environment_5222.html

The Environmental Analysis and Review website is a clearinghouse dedicated to providing information to guide transit and other agencies through the environmental review process for transit projects and improvements that receive federal funds. The website contains detailed information on NEPA and other environmental policies, information on environmental streamlining and stewardship as mandated in Executive Order 13274, and resource information compiled in a NEPA reference library.

Coordination and Collaboration

Disaster recovery situations generally bring together people who may not work together in non-emergency situations. Establishing and reinforcing these relationships before an event occurs and utilizing them to create recovery procedures and communications processes in advance of an event can improve the recovery process.

Checklist, Worksheets, and Toolkits

Sample Transportation Coordination Agreements
This resource provides samples of Memorandums of Understanding and Intergovernmental Agreements to use as structures for local coordinating councils. The samples were prepared by TransitPlus to augment the report "A Handbook for Creating Local Coordinating Councils in Colorado" and are available online at *http://www.njcost.com/2010%20web%20info/2010%20CTAA%20Conference/Intensive%20Training%20Sessions/Developing%20Local%20and%20Regional%20Community%20Transportation%20Coordination%20Councils/1%20-%20MOU%20and%20IGA%20Examples.pdf*

Transit Mutual Aid Agreement Sample
This resource is a sample Memorandum of Understanding that can be used by a Local Transit Agency and another agency. It is available online at *http://transit-safety.volpe.dot.gov/training/Archived/EPSSeminarReg/CD/documents/EmerPrep/MOU.doc*

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Multi-Jurisdiction Mutual Aid Agreement
This Multi-Jurisdictional Mutual Aid Agreement draft is provided as a sample. Jurisdictions should add or delete items as needed to comply with local laws and procedures.
http://sema.dps.mo.gov/docs/programs/Planning,%20Disaster%20&%20Recovery/State%20Public%20Assistance%20Program/mutualaidsample.pdf

Public Works Mutual Aid Agreement Sample
This sample Mutual Aid Agreement is from FEMA and is available at *http://training.fema.gov/emiweb/is/is1Toolkit/Documents%202000/Unit%204/Mutual%20aid%20public%20works.doc*

Guidance and Resources

Mutual Aid and Interlocal Agreement Handbook
Authors: State of Washington, Emergency Management Division
Date Published: 2009
www.emd.wa.gov/plans/documents/MutualAidHandbook.pdf

This handbook explains the difference between Mutual Aid Agreements and Interlocal Agreements. It describes what each type of agreement is best suited to accomplishing particular goals, what should be included in preparation of either agreement, who initiates the agreement, and how to get an agreement executed.

NIMS Intrastate Mutual Aid Training Course (IS-706)
Authors: Emergency Management Institute
Date Updated: June, 2011
https://training.fema.gov/EMIWeb/IS/IS706.asp

This interactive, web-based course provides an introduction to NIMS intrastate mutual aid and assistance. The course explains how to develop mutual aid and assistance agreements and mutual aid operational plans.

Local Government Performance and the Challenges of Regional Preparedness for Disasters
Authors: Brian J. Gerber and Scott E. Robinson, Public Performance & Management Review Volume 32, Number 3
Date Published: March 2009
http://mesharpe.metapress.com/openurl.asp?genre=article&issn=1530-9576&volume=32&issue=3&spage=345

This article discusses the local development of regionalism in emergency management; an approach to assessing the effectiveness of such efforts; and, strategies for assessing the push for regionalism in emergency management, including several regional performance indicators.

Regional Emergency Coordination Plan
Authors: Governor's Office of Emergency Services Cities of Oakland, San Francisco, and San Jose Counties of Alameda, Contra Costa, Marin, Napa, San Mateo, Santa Clara, Santa Cruz, Solano, and Sonoma
Date Published: March 2008
http://www.sfdem.org/ftp/uploadedfiles/DEM/PlansReports/RecoveryAnnex.pdf

The State of California Governor's Office of Emergency Services and its local government partners developed the Bay Area Regional Emergency Coordination Plan to provide a framework for collaboration and coordination during regional events.

Puget Sound Regional Transportation Recovery Annex
Authors: Puget Sound Region
Date Published: February 2011
http://www.seattle.gov/emergency/library/TransportationRCPTApprovedFinal.pdf

The Puget Sound Transportation Recovery Annex (Annex) supplements the Puget Sound Regional Catastrophic Coordination Plan (Coordination Plan). It provides recommended guidelines for coordinating multi-jurisdictional regional transportation system recovery in the Puget Sound Region after a catastrophic incident.

FUNDING

It is important to know in advance what recovery funding resources are available and to understand the eligibility and documentation requirements for obtaining that funding. This section provides tools and resources to better understand recovery funding options and requirements.

Checklists, Worksheets, and Toolboxes

FEMA Public Assistance (PA) Forms Library
http://www.fema.gov/interactive-forms-library
Online forms from FEMA for Public Assistance funds are available on the FEMA site.

Insurance Considerations for FEMA PA Applicants
http://www.fema.gov/public-assistance-9500-series-policy-publications/insurance-considerations-applicants
This resource is a fact sheet that outlines insurance considerations that influence PA grants. Disaster assistance provided by FEMA is intended to supplement financial assistance from other sources. Disaster assistance will not be provided for damage or losses covered by insurance.

Audit Tips for Managing Disaster-Related Project Costs
http://www.emd.wa.gov/disaster/documents/disaster_PA_OIGAuditTips062011.pdf
The Department of Homeland Security (DHS) and the Office of Inspector General (OIG) prepared this guide for recipients of FEMA public assistance and hazard mitigation funds to assist in

- Documenting and accounting for disaster-related costs,
- Minimizing the loss of FEMA disaster assistance program funds,
- Maximizing financial recovery, and
- Preventing fraud, waste, and abuse of disaster funds.

Guidance and Resources

Repairing and Reconstructing Disaster-Damaged Roads and Bridges: The Role of Federal-Aid Highway Assistance
Authors: Congressional Research Service/Robert S. Kirk
Date Published: February 22, 2010
http://assets.opencrs.com/rpts/RS22268_20100222.pdf

This report describes FHWA assistance for the repair and reconstruction of disaster-damaged highways and bridges or catastrophic failures (such as a bridge collapse). It begins with a brief discussion of the legislative origins of federal assistance and describes the Emergency Relief (ER) program in its current form. The report then discusses eligibility issues and program operation and briefly describes the major findings of a recent Government Accountability Office (GAO) report on ER.

FEMA Public Assistance Guide
Authors: Federal Emergency Management Agency (FEMA)
Date Published: June 2007
Date Updated: August 11, 2010
http://www.fema.gov/government/grant/pa/pag07_t.shtm

The FEMA Public Assistance Guide is a user-friendly and comprehensive overview of the scope of assistance available following a disaster. Eligibility requirements and the application procedures and basic provisions of the PA Program are provided, including debris removal, emergency protective measures, and permanent restoration of infrastructure. Because this document is not exhaustive and the provisions are subject to modification, the information provided should be verified with FEMA PA Program officials before becoming the basis for decision making.

Emergency Relief Manual
Authors: Federal Highway Administration (FHWA)
Date Published: November 2009
http://www.fhwa.dot.gov/reports/erm/

This manual is an update of the Emergency Relief Manual from August 2003. It provides updated guidance and instructions on FHWA's emergency relief (ER) program from eligibility of damage repair work to project procedures and requirements. This manual provides information for requesting, obtaining, and administering ER funds. This manual covers only those criteria and procedures applicable to the ER program for federal-aid highways.

Emergency Relief Manual (Federal-Aid Highways) Interim Update August 2003
Authors: FHWA
Date Published: August 2003
http://www.fhwa.dot.gov/reports/erm/erm.pdf

This manual is an update of the Emergency Relief Manual from September 1998 and provides updated guidance as well as instructions on FHWA's emergency relief (ER) program. This manual provides information for FHWA, state, and local transportation agency personnel on policies and procedures for requesting, obtaining, and administering ER funds. This "interim update" manual replaces the Emergency Relief Manual, Publication Number FHWA-PD-98-054, published in September 1998. The manual covers only those criteria and procedures applicable to the ER program for federal-aid highways.

Guide to the Federal-Aid Highway Emergency Relief Program
Authors: Federal Highway Administration (FHWA)
Date Updated: October 29, 2009
http://www.fhwa.dot.gov/specialfunding/er/guide.cfm

This guide helps answer questions relating to The Emergency Relief Program (ER) administered by FHWA. It addresses the FHWA's ability by law to provide up to $100 million in ER funding to a state for each natural disaster or catastrophic failure that is found eligible for funding under the ER program. This guide is primarily laid out like an FAQ, with questions and answers concerning the ER program. It describes how the program works, federal highways and serious damage, repair eligibility, and federal cost share.

Emergency Relief for Federally Owned Roads (ERFO) Overview
Authors: Federal Highway Administration (FHWA)
Date Updated: July 26, 2012
http://flh.fhwa.dot.gov/programs/erfo/

The ERFO Program is designed to cover expenses for the repair and reconstruction of federal roads damaged by a disaster or catastrophic failure for the agencies that manage the roads. The ERFO Disaster Assistance Manual provides detailed program guidance and instructions on how to apply for ERFO funding.

Railroad Rehabilitation and Repair FRA Funding
Authors: Federal Railroad Administration (FRA)
http://www.fra.dot.gov/rpd/freight/2081.shtml

The Consolidated Security, Disaster Assistance, and Continuing Appropriations Act, 2009 (Pub. L. 110-329, September 30, 2008), provided the Secretary of Transportation with $20,000,000 for grants to repair and rehabilitate Class II and Class III railroad infrastructure damaged by hurricanes, floods, and other natural disasters in areas for which the President declared a major disaster under Title IV of the Robert T. Stafford

Disaster Relief and Emergency Assistance Act of 1974. These funds were awarded to states on a competitive, case-by-case basis.

Lower Manhattan Recovery Office
Authors: Federal Transit Administration (FTA)
Date Updated:
http://fta.dot.gov/about/13119.html

The FTA has provided this resource document to introduce the mission of the Lower Manhattan Recovery Office (LMRO), specifically in the aftermath of 9/11. Descriptions of the funding appropriated by Congress to several federal agencies are outlined, including nearly $5 billion in capital construction funding for transportation infrastructure projects. Information is provided about the background of the LMRO and the FTA's involvement, providing technical support and emergency funding in coordination with federal, state, and local agencies. Documents relating to innovative approaches to project development and examples of transportation recovery projects can be found at *http://fta.dot.gov/region2_4154.html*.

FEMA Applicant Handbook
Authors: Federal Emergency Management Agency (FEMA)
Date: March 2010
http://www.fema.gov/pdf/government/grant/pa/fema323_app_handbk.pdf

The Applicant Handbook (FEMA P-323) was developed to provide easy-to-follow instructions on how to apply for Public Assistance grants. Numerous applicants, state emergency managers, and federal public assistance staff requested the development of a handbook to help walk applicants through the procedures and forms necessary to determine eligibility and receive funds.

Emergency Transit Assistance: Federal Funding for Recent Disaster and Options for the Future
Authors: Government Accountability Office (GAO)
Date: February 2008
http://www.gao.gov/new.items/d08243.pdf

Major disasters can disrupt transit operations, destroy vehicles and facilities, and impede the ability of people to reach essential relief and medical services and return to their homes and jobs. GAO determined (1) the federal role in assisting transit agencies after a major disaster; (2) the amounts, sources, and uses of federal disaster assistance for transit since 1998; (3) the factors that affected the timeliness and effectiveness of transit assistance after the 2005 Gulf Coast hurricanes; and (4) additional options for providing assistance to transit after a major disaster. GAO reviewed laws, regulations, and guidance; analyzed DOT and FEMA data; and interviewed officials with FEMA, U.S. DOT, state and local agencies, and others.

FEMA Hazard Mitigation Assistance Unified Guidance
Authors: Federal Emergency Management Agency (FEMA)
Date: June 2010
http://hazardmitigation.calema.ca.gov/docs/FY11_HMA_Unified_Guidance.pdf

Hazard Mitigation Assistance (HMA) Unified Guidance introduces the five HMA Programs and consolidates the common requirements for all HMA programs and explains the unique elements of the programs in individual sections. Additionally, it provides assistance for federal, state, tribal, and local officials on how to apply for HMA funding for a proposed mitigation activity.

Transportation Funding Recovery Case Studies
Authors: U.S. Department of Transportation
Date Published: September 2009
http://www.dot.gov/disaster_recovery/funding_case_studies.html

These case studies, provided through the U.S. DOT's National Transportation Recovery Strategy (NTRS), highlight specific states' responses to a variety of disasters and cover some best practices that have enabled these states to rebuild their transportation infrastructure. Each case study begins with a look at the disaster recovery plan or program implemented within the state, followed by a description of how the plan was executed and how federal funds were leveraged following a disaster. The specific states covered are California, Iowa, Louisiana, Kansas, and Wisconsin.

Stafford Act Disaster Assistance: Presidential Declarations, Eligible Activities, and Funding
Authors: Congressional Research Service, Keith Beas, Specialist in American National Government
Date Published: March 2010
http://assets.opencrs.com/rpts/RL33053_20100316.pdf

This resource is an overview of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (the Stafford Act) that authorizes the President to issue major disaster or emergency declarations in response to catastrophes in the United States that overwhelm state and local governments.

A-60 A Pre-Event Recovery Planning Guide for Transportation

CONTACTS

	Website Link
FEMA Regional Contacts	*http://www.fema.gov/about/contact/regions.shtm*
State Emergency Mgt Office Contacts	*http://www.dot.gov/disaster_recovery/State_Emergency_Management_Office_Contacts.pdf*
FWHA RETCO_RETREP	*http://www.fhwa.dot.gov/keyfield/dotreg.htm*
FHWA Field Services Directory	*https://fhwaapps.fhwa.dot.gov/foisp/keyfield.jsp*
DHS Protective Security Advisors	*http://www.dhs.gov/files/programs/gc_1265310793722.shtm*
MPO Directory	*http://www.ampo.org/directory/index.php*
Local Emergency Planning Committees Database of Local Emergency Planning Committees (LEPCs) can be searched by state, name, or zip code.	*http://yosemite.epa.gov/oswer/lepcdb.nsf/HomePage?openForm*
U.S. Department of Homeland Security Center of Excellence—Coastal Hazards Center (CHC)	*http://hazardscenter.unc.edu/diem/index.php* *http://hazardscenter.unc.edu/*
U.S. Department of Homeland Security Center of Excellence – National Transportation Security (NTSCOE)	*https://www.hsuniversityprograms.org/index.cfm/centers-of-excellence/ntscoe/*
National Voluntary Organizations Active in Recovery	*www.nvoid.org*
Federal Transit Administration	*http://transit-safety.volpe.dot.gov* The Federal Transit Administration (FTA) has developed numerous guidelines for transit professionals responsible for planning for, managing, and recovering from emergencies and disasters**.**
Homeland Security Exercise and Evaluation Program	*https://www.hseep.dhs.gov/default.htm* The Homeland Security Exercise and Evaluation Program (HSEEP) is a capabilities and performance-based exercise program that provides a standardized policy, methodology, and language for designing, developing, conducting, and evaluating all exercises. In addition to providing a standardized exercise policy, HSEEP also facilitates the creation of self-sustaining, capabilities-based exercise programs by providing tools and resources such as guidance, training, technology, and direct support.
The National Transit Institute	*http://ntionline.com/topic.asp?TopicArea=5* The National Transit Institute at Rutgers University has developed a variety of courses to address worker safety and health in the transit workplace. Courses are designed for front-line and supervisory personnel, including a new course tailored to the safety and security needs of community transit providers.

NIMS Integration Center	*http://training.fema.gov/NIMS* The National Incident Management System (NIMS) was developed to give emergency managers and responders unified processes and procedures designed to improve interoperability among jurisdictions and disciplines in command and management, resource management, training, and communications. By Presidential Executive Order, all agencies that receive federal funding must adopt a NIMS-based emergency response protocol, and all first responder organizations, including transit, must train their staff to basic awareness in NIMS. Additional recommended online incident management certificate courses include: *http://training.fema.gov/EMIWeb/IS/is100.asp,* *http://training.fema.gov/EMIWeb/IS/is200.asp* *http://training.fema.gov/EMIWeb/IS/is700.asp*

Other Federal Agency Contacts

U.S. Census Bureau Information on Using Census Data to Plan for Emergencies
http://www.census.gov/Press-Release/www/emergencies/

U.S. Department of Homeland Security Centers of Excellence Program
http://www.dhs.gov/xres/programs/editorial_0498.shtm

National Organizations
AASHTO Page on Transportation Security and Emergency Management
http://security.transportation.org

Surface Transportation and Public Transportation Information Sharing and Analysis Center
www.surfacetransportationisac.org

Associations of Public-Safety Communication Officials Hurricane Resources
http://www.apcointl.org/new/resources/hurricanes.php

APPENDIX B: NCHRP PROJECT 20-59(33) CASE STUDIES

TABLE OF CONTENTS

The limited guidance on pre-event planning for recovery of transportation systems required a compilation of lessons from case studies of infrastructure recovery. Five in-depth case studies were done that represent a cross-section of infrastructure owners and operators. Also completed was a case study based on a few forward-looking jurisdictions that have instituted policies, programs, and tools that can assist in recovery. The states of Michigan, Vermont, and Montana were selected because these states represent examples of the importance of driving asset management with a well-defined strategic planning process that incorporates recovery planning. Lessons and processes/tools for recovery were identified for each case study.

SUMMARY: LESSONS FROM IN-DEPTH CASE STUDIES

Formal/informal relationships and networks were keys to successful recovery.

Based on experiences from previous significant disaster events, Iowa DOT now works closely with multiple federal agencies as a part of the recovery process. For instance, Iowa DOT functions as the coordinator for the FHWA emergency relief program and takes on the responsibility to process the Detailed Damage Inspection Report (DDIR). Recovery from the 9/11 incident in New York City was made possible by using pre-existing relationships, including those of retired personnel and volunteers. In the London 7/7 bombings, the fact that personnel knew each other played a very important role in coordination. In California, a multi-agency working group composed of key asset owners and stakeholders coordinates planning and implementation.

Simplified designs can expedite reconstruction.

After 9/11, lack of architectural detail in the temporary PATH stations allowed bidding on the necessary steel on a per-pound basis before the design was even finished. The conduit carrying the utilities and cabling was left exposed, eliminating the design time needed to artfully bury it. These strategies shaved 1 year off the construction schedule.

Make infrastructure improvements where possible.

Bench walls, lighting and communication enhancements in PATH tunnels after 9/11 in NYC were added during recovery construction. The Baltimore tunnel case study noted the need for upgrading aging infrastructure as part of the rehabilitation of critical infrastructure.

Take a phased approach to recovery.

After 9/11, PATH service to lower Manhattan was provided through a series of temporary transit stations and entrances.

Use existing plans and footprints where possible.

To restore train service to the World Trade Center (WTC) site as quickly as possible, a temporary PATH terminal was built at the same location as the destroyed facility, enabling engineers to utilize previous alignments and reduce additional excavation /foundation work.

Have expedited processes in place for emergencies.

The California Governor's declaration of disaster can ease environmental requirements and other contracting requirements. Emergency contracts can then be rapidly implemented using a ready list of pre-identified and pre-qualified contractors, even before federal funding is available.

Take a collaborative approach to recovery.

After 9/11, collaboration with contractors and designers was part of design and construction. For example, the sequence of construction inside the tunnels was done differently, in a process developed in conjunction with the contractor, who wanted to use rubber-tired equipment to bring in materials. The contractor's desired approach required locating everything first and then laying the track last. To accommodate this, a high level of survey control was developed along with a "clearance jig" to make sure the trains had enough clearance.

Use innovation in project development, oversight, and environmental management.

After 9/11, the FTA Lower Manhattan Recovery Office (LMRO) was created to work on innovative, streamlined project delivery processes with consensus among federal and local partners. Some of these approaches included using one grant for the entire project, developing a Master Agreement for both FTA and FEMA requirements, creating an MOU among federal agencies for environmental oversight, and creating a Federal Interagency Review Team.

Understand interdependency of critical infrastructure as part of the hazard and risk assessment.

The Baltimore tunnel case study illustrated the interdependencies of transportation, communications, and other critical infrastructure. Asset management systems, as discussed in the cases of Michigan, Montana, Ohio, and Vermont can address the issue by helping in maintenance of statewide transportation assets and eliminating system deficiencies.

Maintain and provide access to designs, plans, and other key data.

After 9/11, availability of information on designs, plans and other key data became an issue because key plans and documents were stored in the WTC. For the Howard Tunnel in Baltimore, key tunnel documents were not found until days after the incident. Many roadway and bridge design plans, shop drawings, and other infrastructure record documents are available electronically on a 24-hour basis in Iowa DOT's electronic record management system (ERMS).

Plan for the unexpected by learning from previous experiences.

After the 1993 WTC bombing, every agency and facility put emergency plans in place, but no one had conceived of an event of the enormity and scale of 9/11. Similarly, after the London bombings, planning has been expanded to cover multisite scenarios. For tunnels, water intrusion is a critical issue and infrastructure interdependencies can be identified.

Integrate recovery with existing planning.

Iowa has a State Recovery Plan that includes a Transportation Appendix that details the roles, responsibilities, and framework for post-disaster transportation recovery. In California, the State Emergency Plan includes a Recovery section that Caltrans helped to develop, and recovery is integrated into hazard mitigation planning and COOP efforts.

9/11, NEW YORK CITY, NEW YORK, 2001

EVENT AND RECOVERY SUMMARY

Synopsis of Event

On the morning of September 11, 2001, hijackers flew two 767 jets into the Twin Towers of the World Trade Center complex in a coordinated attack. After burning for 56 minutes, the South Tower collapsed, followed 30 minutes later by the North Tower. 7 World Trade Center collapsed later in the day. An NY/NJ Port Authority Trans-Hudson (PATH) station was connected to the World Trade Center towers via an underground concourse and shopping center. The station also connected to several New York City Subway services, specifically the Number 1 and Number 9 lines. By autumn of 2001, the volume of passengers using the WTC PATH station was approximately 25,000 daily.

September 11, 2001 Event Timeline

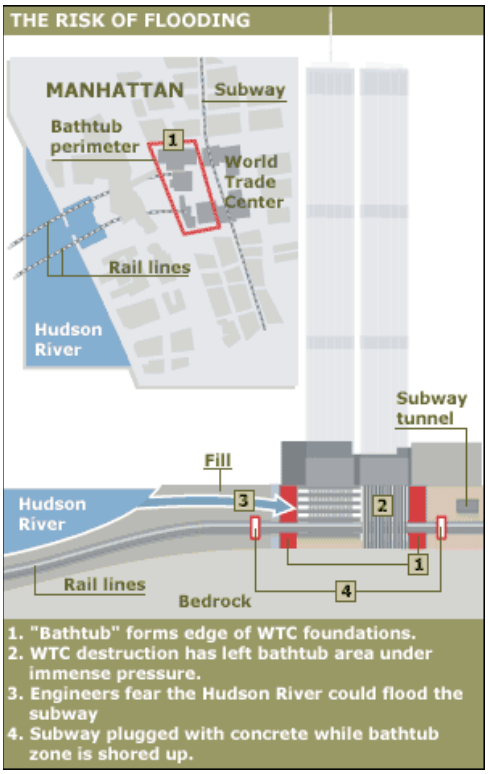
8:46 a.m. Plane hits North Tower
9:03 a.m. Plane hits South Tower
9:17 a.m. FAA shuts down NYC airports
9:17 a.m. Amtrak suspends all service
9:17 a.m. NY DOT shuts down highways
9:21 a.m. Port Authority closes bridges and tunnels
9:40 a.m. FAA grounds all flights
9:43 a.m. Plane hits Pentagon
9:59 a.m. South Tower collapses
10:00 a.m. Armed forces put on high alert
10:20 a.m. NYC Transit shuts down
10:29 a.m. North Tower collapses
10:30 a.m. NJ Transit stops rail service to Penn Station
10:37 a.m. Fourth plane crashes in Pennsylvania
10:45 a.m. All PATH operations stop
10:50 a.m. All remaining bridges and tunnels close

Impact of Event on Critical Infrastructure

When the World Trade Center (WTC) towers collapsed, the WTC PATH station was destroyed, and debris was sent with great force into the tunnels. In several places, individual beams from the WTC weighing several tons punched through the street, into about 7 feet of earth, through the concrete-and-brick tunnel ceiling, and then into the tunnel floor, where they remained lodged like spears. In addition, the tunnels suffered extensive flood damage from broken water and sewer lines and the vast amounts of water used to fight the fires at the World Trade Center. The flooding damaged tracks, cables, electrical components, and concrete from the PATH World Trade Center Station to Exchange Place in New Jersey.

NYC Transit also suffered extensive damage. Four subway corridors were affected, with 1,400 feet of tunnel in Manhattan destroyed. Six miles of water mains were broken, and the 7th Avenue tunnel was flooded in the immediate area. The Cortlandt Street station was completely destroyed. There were problems with power and signals, and continuing fires and collapsing buildings added safety concerns.

Physical damage from the collapse and vibrations, and flooding of some track, put the N and R trains and the Interborough Rapid Transit (IRT) trains out of service, with partial closings on the Lexington Avenue line.



The potential for the Hudson River to create extensive system flooding due to the collapse of the "bathtub" surrounding the WTC site was not anticipated. Concrete tunnel plugs had to be put in place quickly and then removed when the recovery projects were underway. Two 19-foot thick concrete plugs had to be installed at the New Jersey end-of-the-century PATH tubes to contain the water if catastrophic flooding occurred. Two steel-and-concrete plugs, 3 feet thick, were built in the 1 and 9 tunnels near Chambers Street and Cedar Street to prevent water from flowing into the rest of the subway. The plugs were installed because the 1 and 9 tunnels run right up against the western wall of what is called the bathtub wall, the waterproof barrier that rings the World Trade Center basement to keep Hudson River water out and which was threatened by the extensive damage. The figure on the left illustrates the risk of flooding.

With the WTC PATH station destroyed, PATH service to Manhattan was suspended for more than 2 years. The Exchange Place station also had to be closed because it could not operate as a terminus or "terminal" station since it had no capability for allowing trains to change direction.

Restoration of Service

Other transportation operators raced to restore service or develop alternatives for transportation to lower Manhattan. By September 16, New Jersey Transit had designed, taken out permits for, constructed, and begun operations on a new ferry service across the Hudson River. Ferry service provided the flexibility to move people rapidly away from the site on September 11th and provided ongoing transportation in the months that followed. Ferry service was critical to the movement of New Jersey residents to New York City and back after September 11th.

According to the study *Public Infrastructure Service Flexibility for Response and Recovery in the Attacks at the World Trade Center* (Zimmerman, 2003), four factors contributed to the ability of the NYC Transit system and surrounding commuter and long-distance rail lines to recover so quickly in the near term, given the scale and unexpectedness of the disaster:

1. Flexibility in routing, such as re-routing of trains away from the area after the destruction.

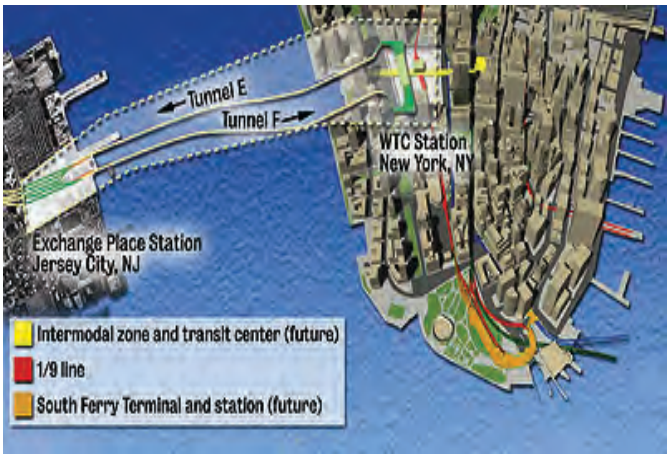
2. Ability to access and use alternative transportation modes such as ferries and buses.
3. Implementation of mechanisms to reduce consequences of disruption by removing passengers rapidly from stopped trains.
4. Ability to draw substantial new resources to rehabilitate the system quickly.

Recovery of Critical Infrastructure

To reestablish service at the former Port Authority Trans-Hudson (PATH) World Trade Center (WTC) Station meant upgrading the Exchange Place Station to accommodate "terminal" rail services, repairing the flooded twin Hudson River tunnels, and constructing a new, temporary WTC station. The new transportation hub was paid for through insurance settlements relating to the events of September 11th and through funds from the states of New York and New Jersey.

The recovery and rebuilding of the World Trade Center transportation facilities had to be coordinated with multiple transportation entities that shared the WTC site. For example, MTA/NYC transit could not design and start rebuilding the destroyed Cortlandt Street Station until the integration with the new PATH transit hub was determined. The station has still not been replaced.

Restoration of Exchange Place



The Exchange Place project included 1,500 feet of new cross-over tunnel construction to allow trains from Newark to reach the Hoboken-bound tunnel and vice versa. Modifications were made to a stub end tunnel, known as the Penn Pocket, which was originally built for short-term runs between the World Trade Center and Exchange Place for Pennsylvania Railroad commuters from Harborside Terminal. The modifications required PATH to bore through the bedrock dividing the stub tunnel and the tunnels to and from Newark. The excavation required removal of 10,000 cubic yards of rock 100 feet below street level, which proved to be a challenge.

The contractors originally intended to blast and drill their way through the rock, as that was the most familiar method to them. However, the Port Authority, which owns PATH and was closely monitoring the production rate, determined that the work was moving too slowly, so they decided to use "road headers"—unique mining equipment resembling a tank, outfitted with a massive rotating grinding ball at the end of a long arm. "We burned a lot of time getting the road headers up and running," concedes Jim Palmer, PE, lead

technical advisor on the restoration of PATH service between the sites. "That was a real lesson we learned. Next time, I'd have my options laid out in advance." The Exchange Place station re-opened in June 2003.

Repairing the Tunnels

The PATH trains into lower Manhattan utilized two existing railway tunnels from when the system was established. The incident did not destroy the tunnels but the damage done required stripping the tunnels down to the cast iron tunnel ring liners—the "Hudson tubes"—and rebuilding from there.

The nature of the tunnels put constraints on what could and couldn't be done and what needed to be done. Space limitations and other extreme conditions restricted the methods that could be used for recovery. Equipment options were limited due to confined spaces, ventilation, and maneuverability. Because of new technologies in track design, the system could not simply be replaced. The new tracks changed the profile of the trains inside the tunnel, where the clearances were already very tight. The change in profile necessitated modifications of the interface points between the tunnels and the stations at either end.

Reconstruction of WTC PATH Station

PATH service to lower Manhattan was restored when a $323 million temporary WTC station opened on November 23, 2003. The temporary station had a utilitarian design that contained portions of the original station and did not have heating or air conditioning systems installed to expedite construction. When the Church Street entrance opened, the temporary station entrance was closed on July 1, 2007, and demolished to make way for the permanent station.

A new entrance to the World Trade Center PATH station on Vesey Street opened in March 2008, and the entrance on Church Street has since been demolished. The permanent World Trade Center PATH station is being completed.

MTA/NYC Transit Reconstruction

The removal of all debris from the collapsed World Trade Center buildings and an open cut excavation including the demolition of the remaining existing concrete structure of the 1 and 9 subway was completed in less than 6 weeks. The reconstruction on the north end included sheeting, bracing, and dewatering of the section running from Barclay Street to Vesey Street near World Trade Center 7. Working from a 1915 design, contractors installed over 2 million pounds of steel bracing and formed and poured over 9,000 cubic yards of concrete for the new subway tunnel and station platforms in the rehabilitation of the Rector Street station. With an aggressive 9-month plan, the project was completed ahead of schedule. Insurance proceeds and federal disaster assistance should cover most of the property losses related to the tragedy.

PRE-EVENT PLANNING FOR RECOVERY

Emergency Plans That Included Recovery Were in Place

After the 1993 incident at the World Trade Center, it was clear that the site was an ongoing target. Emergency plans that included recovery were created and kept up-to-date to address future incidents. Business contingency plans existed in all departments. Arrangements were established with other transportation operators such as NJ Transit and Amtrak, should PATH be unable to operate. MTA and other NYC transit systems developed updated evacuation and rerouting plans.

Planning processes were in place and planning had already included some aspects of addressing recovery, but not for an event on the scale of the 9/11 attacks. Contingency plans existed in all departments to a greater or lesser extent. "Day in the life" experiences and previous incidents and exercises provided opportunities to learn how to quickly respond and recover from service interruption events.

Key resources were available for recovery due to the pre-event planning such as highly specialized signal technology, transformers, and pumps. Equipment was available to maintain the system and to do damage assessment such as vibration checks. However, no one anticipated the level of destruction caused by the attacks of 9/11.

Pre-Defined Organization Roles and Responsibilities Were Identified

The PATH plan identified recovery roles and responsibilities by title. Individuals were aware of their roles, and even though overall responsibility was given to the director/general manager (GM), the GM depended on individual managers to perform their roles and keep the GM informed. Delegation of responsibility was key to the recovery effort, and communication was essential for it to work. Daily meetings were held in the aftermath of the incident.

The ability to draw upon organizational resources was critical to the recovery after 9/11. The enormity of the event was beyond the scale of any plans that had been created. Key

senior personnel were lost along with critical infrastructure. Others had to quickly step up to replace those who were lost. The destruction of the World Trade Center also destroyed or prevented access to the MTA PATH crisis plans, documents, and drawings necessary for response and reconstruction. Knowing and utilizing all organizational resources available, including retirees volunteering for service, made a significant difference in the recovery effort. That difference ranged from obtaining physical supplies and facilities to identifying innovative solutions for asset recovery.

Expedited Internal Procedures Were in Place

What normally took months to complete had to be done in days; therefore, the existing organizational hierarchies and long planning cycles would not work. This was a lesson learned in the aftermath of the 1993 World Trade Center bombing. Rapid recovery required delegating more authority down the line to get things accomplished. A temporary reprieve of established internal procedures was granted to speed up the recovery process.

Related and/or Cascading Effects Were Anticipated

Flooding of the transit tunnels from water main breaks was a known and anticipated aspect of the event in lower Manhattan. Pumping equipment and fans were available and quickly put into operation to minimize damage to the transportation system. However, fire suppression efforts at the site over the many weeks following 9/11 contributed significant additional volumes of water into the tunnels. In addition, the potential for the Hudson River to create extensive system flooding due to the collapse of the "bathtub" surrounding the WTC site was not anticipated. Concrete tunnel plugs had to be put in place quickly and then removed when the recovery projects were underway.

Infrastructure Plans and Key Documents Were Collected in Advance

PATH and MTA had compiled planning documents and drawings for critical infrastructure in the transportation systems. The destruction of the WTC destroyed or prevented access to some of the critical documents and drawings necessary for reconstruction.

Lessons for Recovery

Understand the Impact of Response on Recovery

The on-site crime investigation and debris removal at the site lasted for 8 months due to the forensic investigation and the hazardous materials in the debris. Infrastructure recovery efforts could not begin until the debris removal phase of the event was completed. In addition, debris removal equipment such as large cranes required that the streets and the tunnels below be shored up to support the additional weight. In one instance, NYC transit filled 220 feet of tunnel with concrete that then had to be carved away and removed when the transit recovery began. As previously noted, the concrete

tunnel plugs put in place due to flooding had to be removed when the recovery projects were underway.

Take a Phased Approach to Recovery

The PATH service to lower Manhattan was provided through a series of temporary stations and station entrances as the permanent World Trade Center PATH station was being constructed.

Innovative Use of Equipment

When blasting and drilling through the rock for the tunnel was determined to be moving too slowly, the contractors decided instead to use "road headers," unique mining equipment resembling a tank, outfitted with a massive, rotating, grinding ball at the end of a long arm.

The sequence of construction inside the tunnels was done differently, in a process developed in conjunction with the contractor. Normally, the track would be located first and everything else would be based on that. Because the contractor wanted to use rubber-tired equipment to bring in materials, there was a need to locate everything first and then lay the track last. To accommodate this atypical process, a high level of survey control was developed along with a “clearance jig” to make sure that once the track was placed, the trains wouldn't hit anything.

Identify Options in Advance

"We burned a lot of time getting the road headers up and running," concedes Jim Palmer, PE, lead technical advisor on the restoration of PATH service between the sites. "That was a real lesson we learned. Next time, I'd have my options laid out in advance."

Use Simplified Designs to Expedite Recovery

The Port Authority started by using simplified designs that allowed for ordering longer lead-time materials before the contractor was even hired. The lack of architectural detail in the temporary PATH stations allowed bidding on the necessary steel on a per-pound basis before the design was even finished, which shortened the time it usually takes to receive materials. In addition, the conduit carrying the utilities and cabling was left exposed, eliminating the design time needed to artfully bury it. Those strategies shaved 1 year off the construction schedule.

To facilitate the quickest restoration of service possible, some customer amenities were not made available. All public access areas and track zones were open, but they were weather protected. There were no public toilets, shops, or eateries, but the terminal was fully ADA compliant and accessible.

Use Existing Plans and Footprints Where Possible

In order to restore train service to the world Trade Center site as quickly as possible, a temporary PATH terminal was built at the same location as the destroyed facility. This enabled engineers to utilize previous alignments and minimize additional excavation and foundation work. The track and platform configuration of the temporary station followed the former station.

Make Infrastructure Improvements Where Possible

Bench walls, lighting, and communications were enhanced in PATH tunnels where possible. Because of time and spatial limitations, sensors, hardening, and other water-management capabilities were not installed as part of reconstruction and will have to be done in the future.

A new traction power substation located adjacent to the former South Tower footprint was designed to support future construction of floor levels up to the street level. This "over build" scenario was intended to eliminate the need for building future support columns throughout the substation in the ongoing development of the World Trade Center site.

Perform a Post-Recovery Evaluation

Changes were made based on the post-event evaluation conducted after the event. For example, a separate Office of Emergency Management was established by the Port Authority of NY/NJ to develop additional planning capabilities for catastrophic events. Prior to 9/11, this planning was done within the police and individual Port Authority departments.

PROCESSES AND TOOLS

Lessons from Previous Incidents and Exercises

“Day in the life” experiences and previous incidents and exercises provided opportunities to learn how to quickly respond and recover from service interruption events.

Collaborative Approach for Design and Construction

With resumption of PATH service to downtown Manhattan as its top priority, the Port Authority forged a unique partnership that allowed contractors to order materials and mobilize for construction even as engineers were completing design work.

Lead technical designer Jim Palmer has noted that "when we brought the contractors on board, all we had were preliminary designs. We developed a contract packaging strategy by looking at how all this would be built and then arrived at design packages that would support that strategy."

For example, they decided to use all rolled sections for the structural steel of the World Trade Center Station, because it would not require time-consuming fabrication. Framing plans were developed based on that and went out to bid without a complete design. The contractor also went out to bid on the electrical equipment for the electrified railroad without room layouts, although the schematic layout and the capacity of the system were known.

As previously noted, the sequence of construction inside the tunnels was developed in conjunction with the contractor.

Innovative Approaches for Contracting, Design, and Construction

The Port Authority needed to compress the timetable for every aspect of the job, from budget authorization and contracting to design and construction. First, the Port Authority completed cost estimates very quickly to present a budget for approval. Budget authorization alone for a project this large can take a couple of years. The Port Authority completed the process in just 4 months.

Hiring three contractors under a single net-cost, fixed-fee, construction contract (based on time and materials, plus a fixed fee for profit and overhead) also greatly simplified and accelerated the process, although it changed the way business was typically conducted.

"Normally, a net-cost contract will be converted to a lump-sum contract after 10% to 15% of the work is done," explained Palmer. "We converted small parts of the contract, but very little, because there simply wasn't time."

They awarded a net-cost, fixed-fee, construction contract to a team of three contractors and worked with the contractors to design the project while construction was under way, eliminating the need for a lengthy design process. The strategy was so successful that the World Trade Center station was up and running 1 month early, and the rest of the project was completed on time.

Innovation in Project Development, Oversight, and Environmental Management

Due to the urgency of rebuilding these high-priority projects in lower Manhattan, the FTA Lower Manhattan Recovery Office (LMRO) was created to work with the project sponsors on innovative, streamlined, project delivery processes with consensus among federal and local partners. Some of these innovative approaches included the following:

- Project Development
  - Using one grant for an entire project.
  - Developing an LMRO specific master agreement that eliminated different sets of requirements (i.e., FTA vs. FEMA) and two sets of paperwork.

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  - Creating an early partnering agreement between FTA and each project sponsor that established environmental actions and project scope, schedule and budget, and project oversight protocols.

- Project Oversight
  - Creation of an oversight team with members drawn from FTA staff and contractors to focus on project management oversight (PMO), financial management oversight, procurement systems reviews, and environmental processes.
  - Development of a "manage to the risk" oversight approach by FTA to customize the level and type of oversight for each project.
  - Use of a contractor-developed risk assessment profile approach to measure adequacy of time and contingency for building each project.
  - Construction agreements between FTA and project sponsors addressing project scope, schedule, and budget that provide a streamlined approach to project management.

- Environmental Management Oversight
  - Memorandum of Understanding (MOU) with other federal agencies defining roles and response times.
  - Federal Interagency Review Team established to expedite agencies' reviews and comments.
  - Agreement developed among project sponsors committing to a common Environmental Analysis Framework, Environmental Performance Commitments, and a coordinated cumulative effects analysis.
  - Coordinated approach among federal agencies to initiate the Section 106 review process under the National Historic Preservation Act (NHPA) for the World Trade Center Site.

Solve and Prevent Problems with Communications

One key to success in both preventing and solving problems was communication. Daily meetings were held within the transit organizations. Weekly meetings were held with the contractor, project managers, and, depending on the issue, the designers. Jim Palmer explained, "Normally, you have construction meetings with a smaller group of people, and you rely on documentation to relay the information. We defined everything on everybody's hot list to lay problems on the table. Then we went back to solve the problems; immediately, if there were emergencies."

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LONDON TRANSIT BOMBING, LONDON, UK, 2005

EVENT AND RECOVERY SUMMARY

Synopsis of Event

At 8:50 a.m., during the morning rush of July 7, 2005, three bombs exploded within 50 seconds of each other on three different London Underground (tube) trains. Fifty-seven minutes later, at 9:47 a.m., a bomb detonated aboard a double-decker bus in Tavistock Square. The bomb attacks—often referred to as 7/7, killed at least 50 people and injured 700—were the deadliest in London since World War II and tested emergency responder training and tactics.

July 7, 2005, Event Timeline

8:50 a.m. 3 bombs explode in less than a minute on each of 3 London Underground trains.

9:19 a.m. *Code Amber Alert* issued; all train drivers directed to halt at platforms and evacuate passengers.

9:46 a.m. *Red Code* declared; entire Underground network shut down; trains returned to stations; all service suspended.

9:47 a.m. Bomb explodes on double-decker bus in Tavistock Square.

- **Eastbound Circle Line.** The first bomb exploded on an eastbound train travelling between Liverpool Street and Aldgate. Train no. 204 had left King's Cross St. Pancras about 8 minutes earlier. At the time of the explosion, the third carriage of the train was approximately 100 yards (90 m) down the tunnel from Liverpool Street. The blast also damaged a parallel track—the Hammersmith & City Line from Liverpool Street to Aldgate East.

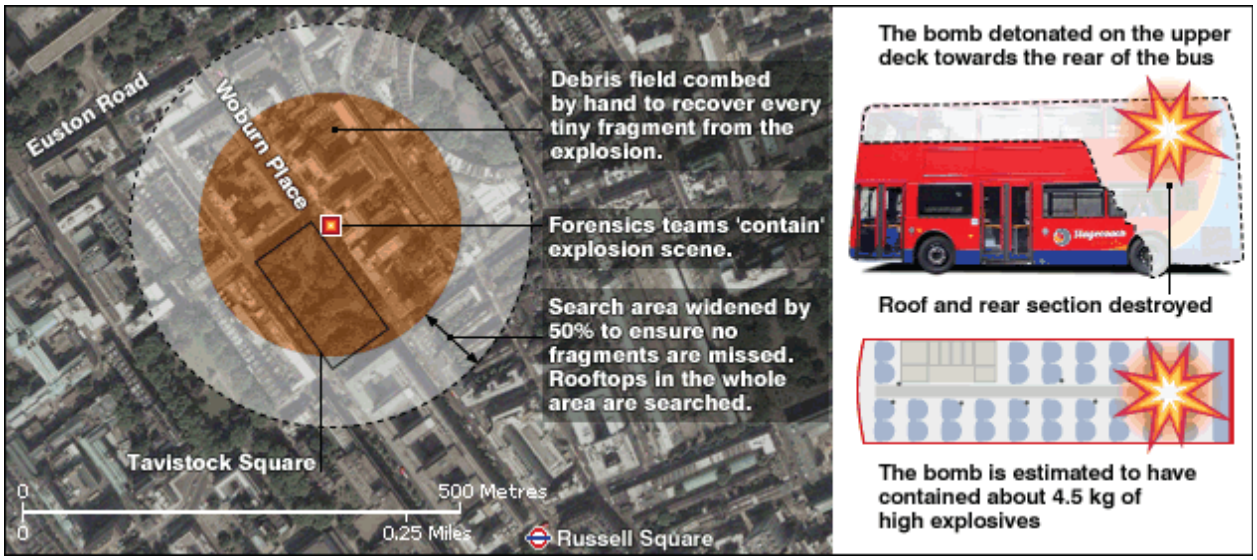
- **Westbound Circle Line.** The second bomb exploded in the second carriage (no. 216) of a westbound Circle Line subsurface train that had just left Platform 4 at Edgeware Road headed for Paddington. The train had left King's Cross St. Pancras about 8 minutes earlier. Several other trains were nearby at the time of the explosion—an eastbound Circle Line train arriving at Platform 3 at Edgeware Road from Paddington was passing next to the train and was damaged, as was a wall that later collapsed. Two other trains at Edgeware Road were an unidentified train on Platform 2 and a southbound Hammersmith & City Line train that had just arrived at Platform 1.

- **Piccadilly Line.** The third bomb exploded on a southbound Piccadilly Line deep-level Underground train no. 113 as it travelled between King's Cross St. Pancras and Russell Square. The bomb exploded about 1 minute after the train left King's Cross and had travelled about 500 yards (450 m). The explosion was in the rear of the first carriage of train no. 166; it caused severe damage to the rear of that carriage, as well as to the front of the second carriage. The surrounding tunnel also sustained damage.

Because the blasts occurred on trains that were between stations and the wounded were emerging from both stations, responders originally thought there had been six explosions at two different Underground stations.

At 9:47 a.m., a bomb exploded aboard a double-decker bus in Tavistock Square. The bus had earlier passed through the King's Cross area on its route from Hackney Wick to Marble Arch, had turned around, and was starting the reverse route. The bus left Marble Arch at 9:00 a.m. and arrived at Euston bus station at 9:35 a.m., where crowds of people evacuated from the Underground were boarding buses.

The bus was not traveling its normal route at the time of the explosion; it was in Woburn Place because its usual route along Euston Road was closed as a result of the earlier bombing of the Piccadilly Line train between King's Cross and Russell Square.



The bus bomb exploded toward the rear of the vehicle's top deck, ripping the roof off the top deck and totally destroying the back of the bus. The front of the bus remained intact. Witnesses reported seeing "half a bus flying through the air."

Impact of Event on Infrastructure

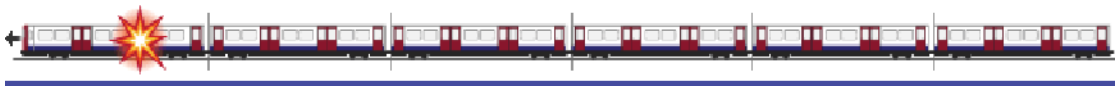
The effects of the bombings on the infrastructure varied because of the differing characteristics of the tunnels.

- The Circle Line is a cut and cover subsurface tunnel, about 21 ft (7 m) deep. Because the tunnel contains two parallel tracks, it is relatively wide. The two explosions on this line were probably able to vent their force into the tunnel, thus reducing their destructive force.

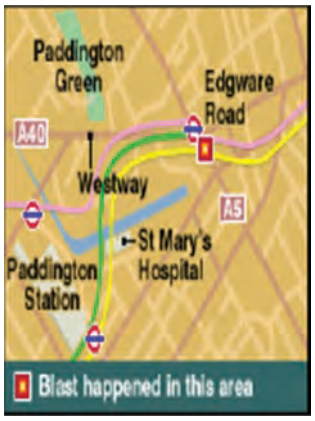
Aldgate/Circle Line: Explosion in second carriage by first set of double doors.

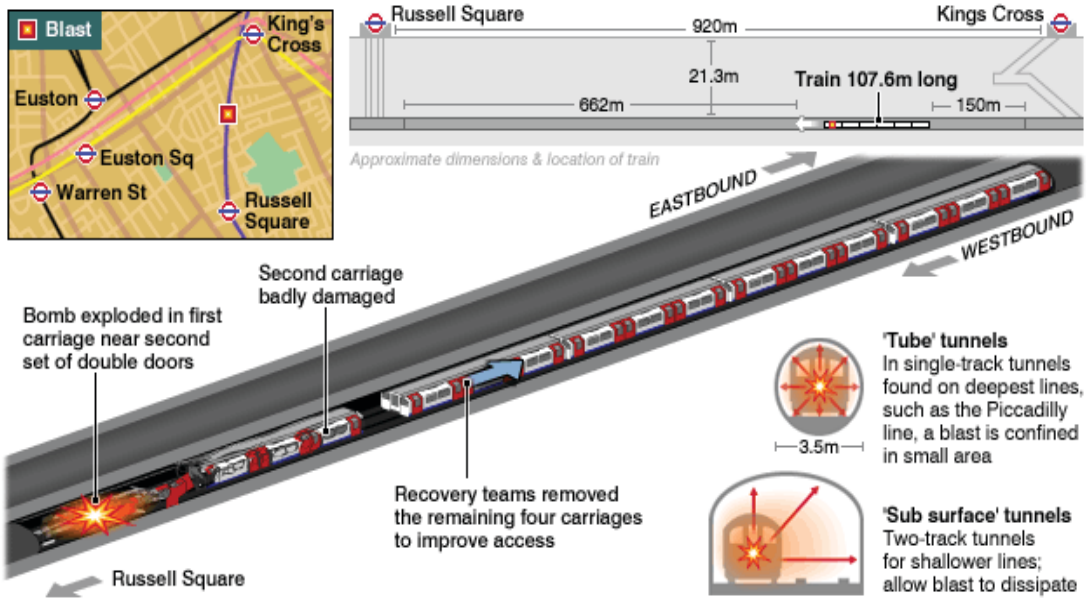
Edgeware Road/Circle Line: Explosion in second carriage by first set of double doors.

- The Piccadilly Line is a deep Tube tunnel, up to 100 ft (30 m) underground, with narrow (11 ft, 8¼ in. or 3.56 m) single-track tubes and just 6 in. (15 cm) clearances. This confined space reflected the blast force, concentrating its effect. Intense heat as high as 60ºC (140 ºF), dust, fumes, vermin, asbestos, and initial concerns that the tunnel might collapse delayed extraction of bodies along with the forensic operation.



Russell Square/Piccadilly Line: Bomb exploded in first car.





Restoration of Service

For most of July 7, the complete closure of the underground system, including shutting down the Zone 1 bus networks and the evacuation of Russell Square, effectively crippled Central London's public transport system. Bus services restarted at 4:00 p.m. that day, and most service to mainline train stations shortly thereafter. Officials pressed tourist river vessels into service as a free alternative to the overcrowded trains and buses. Most of the Underground, apart from the affected stations, reopened the next morning, although some commuters chose to stay at home.

Recovery Timeline

July 7, 4:00 p.m. Bus service restored; most mainline trains reopen for service. Tourist river vessels provide free alternative to trains and buses.

July 9. King's Cross Station service fully restored.

July 15. Victoria Line service restored.

July 18. Northern Line service restored.

August 2. Hammersmith & City Line resumes normal service.

August 4. Piccadilly Line resumes normal service.

King's Cross station reopened later on 7/7, but only suburban rail services were able to use it, with Great North Eastern Railway (GNER) trains terminating at Peterborough (service was fully restored July 9). The King's Cross St. Pancras station remained open to Metropolitan Line services only to facilitate the ongoing recovery and investigation effort for a week. Victoria Line services were restored on July 15 and Northern Line services on July 18.

By July 25, there were still disruptions to the Piccadilly Line (which was not running in either direction between Arnos Grove and Hyde Park Corner), the Hammersmith & City Line (running shuttle service only between Hammersmith and Paddington), and the Circle Line (service suspended in its entirety). Most of the Underground network,

however, was running normally. Although service remained suspended on the Circle Line, other lines served all Circle Line stations. The Circle Line remained closed for several weeks, reopening a little less than a month after the attacks, on August 4. The Piccadilly Line resumed service August 4.

Recovery of Critical Infrastructure

Even though the incident teams had shifted from the Rescue Phase (led by fire services) into the Evidential Phase (led by the Police), recovery activity was being coordinated in the background. The major challenge to recovery was the need to seal the incident sites so investigators could collect evidence. Retaining evidence was a top priority for all parties. Some structural damage assessments were made, as necessary, to ensure the safety of the investigative team, but the required engineering response to address infrastructure damage could not occur until the police cleared each site.

The London Underground Recovery Team was able to plan for structural surveys and determine specific equipment needed for the recovery. Permission was granted for equipment to be brought to the site, and plans were made to bring in equipment such as large cranes in a manner that did not interfere with the investigation.

It was clear from structural damage on the Edgeware Road train that a crane would be necessary to remove the train from the scene. Permission was granted early to bring in the crane and crews began pouring the cement needed to reinforce the above ground supporting structure where the crane would be placed for that operation.

From previous train crashes, Transport for London (TfL), operator of the London Underground (LU) knew how to access and mobilize the necessary specialized equipment and was able to have contracts in place quickly for the 7/7 recovery.

Pre-Event Planning For Recovery

Emergency Plans That Included Recovery Were in Place

The London Underground had continuity, emergency, and recovery plans in place at the time of the incident and immediately put those plans into practice. As Andy Barr noted, “those plans worked.”

Pre-event planning anticipated an intentional attack on the transit system, but at the time, planners may have placed more focus on a different type of attack (such as chemical).

Pre-Defined Organization Roles and Responsibilities Were Identified

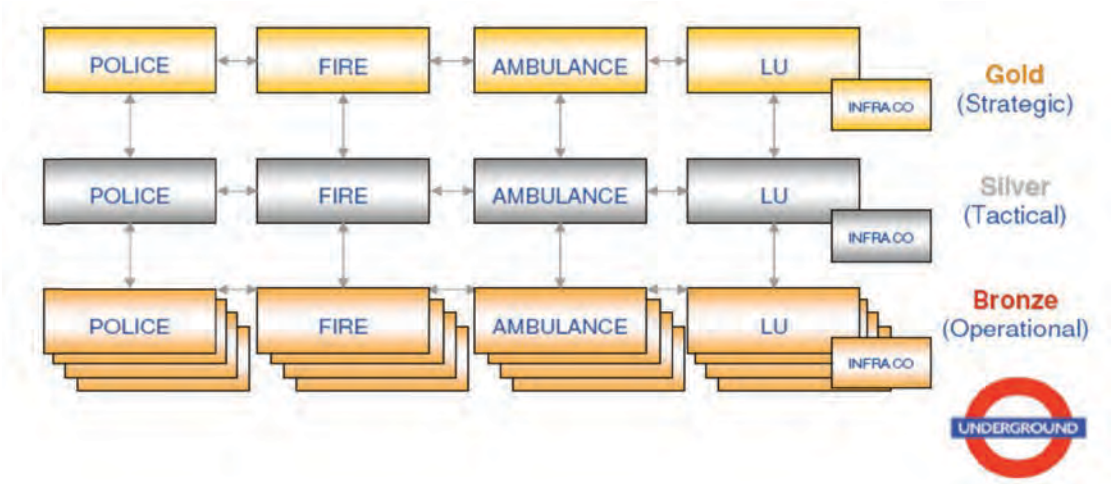
The London Emergency Services Liaison Panel (LESLP), with representatives from the London Metropolitan Police Service, City of London Police, British Transport Police, London Fire Brigade, London Ambulance Service, and local London authorities, produced a Procedures Manual that documents a well-established process for incident response.

The manual defines "major incident" broadly so that any emergency response agency can declare a major incident and thus increase the likelihood that multiple agencies will respond immediately. A key facet of the London bombing response was rapid recognition and declaration of a major incident.

The Procedures Manual details a *Gold/Silver/Bronze* (Strategic/Tactical/Operational) incident management structure that describes the responsibilities of each agency during any major incident and defines the general roles that relevant personnel perform at the scene. An incident has a number of phases, from rescue through recovery and restoration of normality.

At the Silver level, different agencies have primary responsibility for different phases. For example, during the rescue phase, the fire services handle primary lead; the asset owner has responsibility for the recovery phase. Consequently, relevant agencies are familiar with the roles and responsibilities of each level and who has primary responsibility during the various phases of an incident. In addition, all agencies have agreed that U.K. law enforcement serves as the coordination lead. Thus, there is no confusion about which agency is in charge during a major incident.

Transport for London (TfL), operator of the London Underground, has a parallel in-place response structure that is integrated into the LESLP response structure. The London Underground (LU) represented the asset owner, or Infrastructure Companies (InfraCo).



According to Andy Barr, Network Coordination Manager and London Underground Gold during 7/7, there was "an urgent need for London Underground to respond on the day

both as a system and in conjunction with the emergency services and other transport partners."

Because these procedures were in place at the time of the 2005 bombings, there was limited confusion about the roles and responsibilities of responding agencies.

Training Exercises Had Taken Place

Tim O'Toole, the former TfL Managing Director, is convinced that planning exercises conducted prior to the event created a shared knowledge across the various agencies as to who would do what, which permitted the transit network to return to operations relatively quickly. Others involved in the response to and recovery from the incident shared this opinion. O'Toole concluded, "Everyone knew the plan, everyone knew one another. That is why it worked so well."

Knowledge Was Gained from Previous Experiences

Although the response to and recovery from incidents of the scale of 7/7 require massive amounts of resources that are not typically available for smaller incidents, there is knowledge gained that can be applied to both similar events and more catastrophic ones.

A number of rail crashes in the U.K., especially from 2003 to 2004, provided knowledge, experience, and approaches that were incorporated into the response and recovery on 7/7.

From the previous train crashes, the transit system understood what was needed for recovery—large equipment, roads to access the site, repair of infrastructure and signaling equipment, and ensuring the safety of the recovery team. Although the logistics are specific to the location and circumstances of each event, plans can be created in advance for each key element.

Lessons for Recovery

Understand Overlapping Phases of Response and Recovery

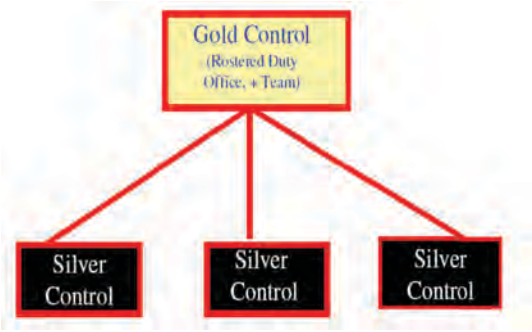
A key to the London transit system's rapid recovery was how quickly the recovery team was able to begin its work at the scene. After all survivors were led to safety (approximately 4 hours after the rescue teams arrived), planning for the recovery became part of the incident team's consideration. The London Underground Recovery Team was given space to begin its project management activities, and access arrangements were made for the structural engineers to determine damage. Permission was granted to bring equipment needed to the site in a manner that did not interfere with the investigation.

Unanticipated Challenges in Managing Multiple Recovery Sites

Pre-event planning did not anticipate incidents at multiple locations. There were unanticipated challenges in managing the recovery at the three different sites even though

a recovery management structure (*Gold/Silver/Bronze* or Strategic/Tactical/Operational) was in place.

A Recovery Gold was appointed on a shift basis across all sites, and Recovery Silver controls were appointed at each site on a 24-hour basis. A Service Director was assigned the sole role of recovery, with day-to-day operations separated from the recovery role. Twice daily conference calls with all participants to monitor recovery progress established a communications and status system. This structure was effective in managing the three sites, but strained operation resources.



Emergency Evacuation Process Caused Unexpected Problems in Reinstituting Service

The emergency evacuation process implemented under the Service Alert caused unexpected problems in reinstituting service. Because drivers had been instructed to stop their trains at the nearest station and to evacuate the station, trains were scattered throughout the network. Issues arose in how to locate the drivers and get them to the stations to bring the trains back to the depot. As there was no service, traffic around the city was gridlocked. Officials made arrangements for assistance with non-affected transportation companies.

Processes and Tools

Pre-Event Recovery Strategy

The London Underground had an established recovery strategy with pre-defined steps (listed in the sidebar). To implement that strategy, officials prepared a Recovery Plan with procedures and templates, which is frequently reviewed. The Recovery Plan's two components—(1) Operational Assets and (2) Buildings/Infrastructure—are merged into one complete Business Recovery Integrated Approach, displayed below.

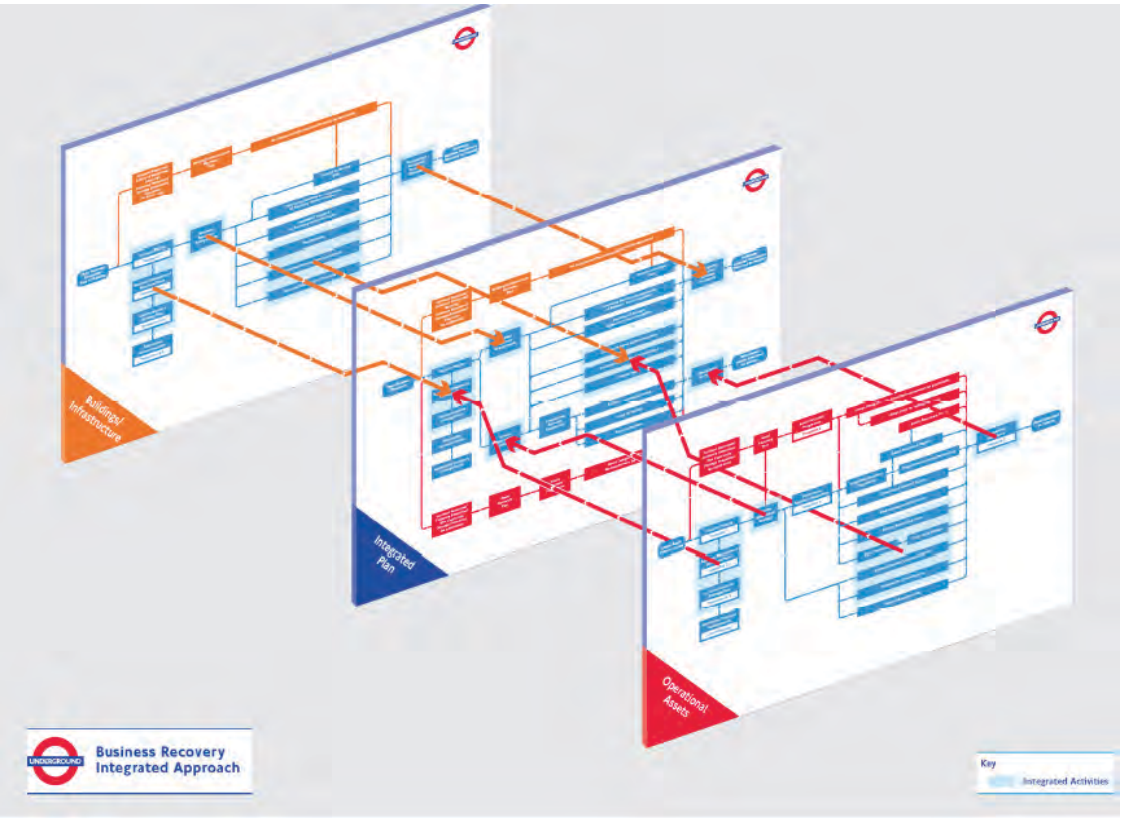
London Underground Recovery Strategy

1. Assess scene.
2. Estimate damage to rolling stock/infrastructure; develop project plans/repair timelines.
3. Communicate with customers, staff, and stakeholders.
4. Remove damaged rolling stock to a secure location.
5. Repair and test infrastructure damage.
6. Hand back assets and return to service.

Use a Series of Templates That Provide Recovery Options—a Series of Considerations—Instead of Decision Trees

To implement the recovery strategy, officials have prepared a Recovery Plan with procedures and

templates, which is frequently reviewed. Templates are created for Operational Assets and Buildings/Infrastructure. Each template provides the pros and cons of actions/approaches for different scenarios. The templates provide the benefit of thinking through the consequences of actions and developing plans for use when an incident occurs.



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HOWARD STREET TUNNEL FIRE, BALTIMORE, MARYLAND, 2001

EVENT AND RECOVERY SUMMARY

Synopsis of Event

At 3:08 p.m. on the afternoon of Wednesday, July 18, 2001, a portion of a 60-car CSXT freight train derailed in the Howard Street Tunnel, causing a major fire. A separation was found between the 45th and 46th cars, and cars 45 through 54 were derailed. Four of the 11 derailed cars were tank cars. One contained tripropylene, a flammable liquid; two contained hydrochloric acid; and another contained di(2-ethylhexyl) phthalate, which is a plasticizer and an environmentally hazardous substance. The derailed tank car containing tripropylene was punctured, causing the escaping tripropylene to ignite, which in turn ignited adjacent cars loaded with paper, pulpwood, and plywood.

At 3:08 p.m., the train crew experienced an uncommanded (not applied by the crew) emergency air brake application and the lead locomotive stopped in the tunnel about 1,850 feet from the east portal.

Per CSX standard and emergency operating procedures, the engineer and conductor attempted to radio the CSX dispatcher to provide notice that the train had stopped in the tunnel. Due to an apparent "dead zone" in the tunnel, with no radio contact, they were unable to reach the train dispatcher. At 3:13 p.m., the conductor used his cell phone to reach the Baltimore trainmaster at CSX and reported that the train had

July 18, 2001, Event Timeline

3:08 p.m. 60-car CSXT freight train with hazardous materials derails in the Howard Street Tunnel.

3:13 p.m. Conductor uses cell phone to report incident to CSX after radio failure due to "dead zone" in tunnel.

3:26 p.m. Train crew returns to lead locomotive to move locomotives and train cars (not derailed) out of tunnel.

4:00 p.m. Baltimore 911 receives a call reporting smoke coming from a sewer near the Howard and Lombard Street intersection, nearly an hour after the incident.

4:00 p.m. CSX chief dispatcher telephones the CSX police communications center asking that emergency response personnel be dispatched to the tunnel.

4:04 p.m. Call to the Baltimore 911 operator, who ultimately notified the Baltimore City Fire Department.

4:20 p.m. Chief of Fire Department requests that all major roads (I-395, I-83, US-40) into Baltimore be closed.

4:30 p.m. Howard Street and all streets crossing over the Howard Street tunnel are closed. I-395 northbound and I-83 southbound are closed to traffic heading into the city.

5:00 p.m. U.S. Coast Guard closes Inner Harbor to boat traffic.

6:15 p.m. Water main break floods the tunnel with estimated 14 millions of gallons of water. MTA closes Metro's State Center station due to smoke.

8:00–9:00 p.m. Roads and entrance/exit ramps on major thoroughfares into the City reopen.

11:59 p.m. 40-inch valve east of the water main break and other auxiliary valves were closed.

Monday, July 23, 7:42 a.m. Incident commander declares scene officially under control.

come to a stop in the tunnel. From there, the trainmaster contacted the CSX dispatcher in Jacksonville, Florida, to report that the train had stopped.

When a train has experienced an uncommanded emergency stop, CSX procedures require that the train crew disembark and walk the train to find the problem. This procedure was cut short due to thick black smoke.

At approximately 3:26 p.m., the train crew returned to the lead locomotive and recharged the air brake system in order to move the locomotives and the train cars that had not derailed (located in front of the first derailed car). They moved eastward out of the tunnel and stopped the train about 450 feet beyond the east tunnel portal (the Mt. Royal portal).

The derailment occurred almost directly below the intersection of Howard and Lombard Streets. The location was 6,223 feet from the eastern entrance to the tunnel, near the University of Baltimore/Mt. Royal Light Rail Station of the Maryland Transit Administration Central Light Rail Line (CLR). The CLR runs along Howard Street between the University of Baltimore/Mt. Royal Station at the north end and Camden Yards Station at the south end.

Subsequent to the fire, there was a break in a 40-inch water main almost directly above the derailment that flooded the tunnel with an estimated 14 millions of gallons of water.

The fire and water main break impacted the Central Light Rail Line, a light rail track in downtown Baltimore, which runs directly over the Howard Street Tunnel and the water main. When the water main broke and the area around the break collapsed, much of the foundation support for this section of the light rail track was damaged. In addition, the main break created a barrier that cut the light rail line in half, isolating rolling stock on the southern segment. MTA established a temporary maintenance facility since the stock on the southern portion could not reach the maintenance facilities. Throughout the period, MTA was able to keep all light rail equipment operational.

On July 21, emergency personnel were able to remove three cars from the tunnel with their contents still burning, and emergency responders were able to contain and extinguish the fire over the next 2 days.

Recovery of Critical Infrastructure

The initial clean up from the tunnel fire took approximately 5 days. All cars were removed from the tunnel and inspected for damage, and all hazardous materials were off-loaded and removed. The tunnel was inspected for structural damage and reopened to rail traffic on July 23. Over the next 3-week period, the tunnel was periodically closed for maintenance, repair, and clean-up. Freight movement was delayed during these closures.

The major transportation infrastructure impact from the tunnel fire was on the Central Light Rail Line. The light rail track in downtown Baltimore runs directly over the Howard Street Tunnel and the water main. When the water main broke and the area around the break collapsed, much of the foundation support for this section of the light rail track was damaged. The light rail track is embedded on a concrete slab, but much of the fill underneath the slab was washed away or collapsed.

In order to gain access to the water main, the light rail track and the supporting concrete slab had to be cut. Once the water main had been repaired, the track itself had to be repaired and shored up, and the new concrete slab had to cure. MTA also had to determine if the area impacted by the water main break remained solid under the light rail track. MTA used ground-penetrating radar to determine whether there were substantial voids (holes or gaps) in the soil below the track bed. Once the slab of concrete with the embedded light rail was replaced, grout was injected to ensure that any small holes were filled.

The event had an unexpected benefit for the MTA. As part of the repairs, MTA implemented a proposed fix for a previously identified problem. Vibration of the light rail tracks against the concrete slab rail bed had been loosening the fasteners that held the track to the slab. During the shut-down, a rubber boot was inserted between the rail and the slab.

Completing repairs to the water main took 12 days. The reconstruction of the light rail bed and tracks took 53 days.

Critical Infrastructure Cross-Impacts of Event

Flooding collapsed several city streets, knocked out electricity to approximately 1,200 Baltimore Gas and Electric customers, and flooded nearby buildings. The Howard Street Tunnel housed an Internet pipe serving seven of the biggest U.S. Internet Information Service Providers (ISPs), which were subsequently identified as those ISPs experiencing backbone slowdowns. By its second day, the high-temperature fire melted a pipe containing fiber-optic lines passing through the tunnel, disrupting telecommunications traffic on a critical New York-to-Miami axis. The severed cable was used for voice and

data transmission, causing backbone slowdowns for ISPs such as Metromedia Fiber Network, Inc.; WorldCom, Inc.; and PSINet, Inc. Reports were received all along the east coast about service disruptions and delays. Cell phones using MCI networks in suburban Maryland failed. New York-based Hearst Corporation lost its e-mail and the main access to its web pages. Slowdowns in communications were experienced in Atlanta, Seattle, and Los Angeles and even as far away as the American embassy in Lusaka, Zambia, which lost all contact with Washington, DC.

Lessons for Recovery

Interagency Coordination and Communication Is Critical

In general, the Baltimore Fire Department was well prepared to respond to emergencies within the city. They participated in trainings and drills and, in fact, had completed a full-scale drill, using an MTA-MD MARC Train in an Amtrak tunnel, approximately 6 weeks prior to the actual incident. They had also conducted drills in MTA-MD's Metro tunnels in prior years. These drills had familiarized fire and emergency medical personnel with tunnel operations and MTA-MD personnel and fostered a positive relationship.

However, the Baltimore Fire Department had never participated in exercise trainings or drills in the Howard Street Tunnel and had never done a preparedness drill with CSX involving hazardous materials before the Howard Street Tunnel incident.

In the Baltimore CSX train derailment, the standard and emergency operating procedures for the train engineer required notifying CSX directly, upon which the CSX dispatcher would then contact the Baltimore Fire Department. Because of the communication difficulties inside the tunnel, which delayed the initial contact with the CSX office, and the routing through the CSX main office, the first call to 911 came from a security guard at a hotel above the incident site. It was not until 4:00 p.m., almost an hour after the incident occurred, that Baltimore 911 received a call reporting smoke coming from a sewer near the Howard and Lombard Street intersection. Baltimore Fire Department responders were dispatched and were able to trace the smoke to the Camden (west) tunnel portal.

Also around 4:00 p.m., the CSX chief dispatcher telephoned the CSX police communications center to ask that the Baltimore City Fire Department be notified and emergency response personnel be dispatched to the tunnel. The time lapse stemming from the incident occurrence, the delay in notification to the CSX dispatcher due to the "dead zone," the verification of the incident by the dispatcher, the call to CSX railroad police, and the 4:04 call to the Baltimore 911 operator, who ultimately notified the Baltimore City Fire Department, all contributed to critical delays in response. Fire department personnel responded to the site at the Mt. Royal portal at about 4:10 p.m., but they could not enter the tunnel because of the fire and smoke.

This delay had a profound impact on the spread of the fire, giving it time to smolder and expand to flammable cargo in the train cars behind the punctured tanker. Had there been immediate notification of the derailment, Fire Department personnel may have been able to contain the chemical spill, suppress the fire, and prevent the water main break, thus reducing the arduous tasks and costs of a multiple-day response to the incident. The number and type of agencies involved quickly adapted to the circumstances, providing support to each other, especially in the recovery phase.

Limited Tunnel Access and Alternate Routes

Because of the age of the tunnel, there were only two entrances at either end. The tunnel had not been modernized to improve access. Several studies have recommended that the freight route for the Eastern Seaboard of the United States be realigned so as not to pass through aging structures such as the Howard Street Tunnel. Speed and capacity are limited because of the age and design of the tunnel.

Currently, there is no parallel routing for freight trains to follow if the tunnel is out of service. Rerouting causes delays and rail congestion. The lack of parallel routing is a significant oversight and deficiency of the freight rail network on the U.S. Eastern Seaboard. Incremental repairs to the existing tunnel, other than for purposes of safety and operational continuity, do not address the limitations of the structure.

A study conducted by U.S. DOT in 2005 recommended that freight service be removed from the Howard Street Tunnel and that the structure be updated to provide double-track, high-clearance routes through Baltimore for freight.

Lack of Critical Information due to Poor Configuration Management and Information Exchange

Prior to the event, information about modifications and construction in or near the tunnel had not been reliably documented or exchanged among city officials, responders, and private industry. Information provided by the City of Baltimore indicated that a storm sewer was 19 feet below the surface near where a test drilling was proposed as part of the recovery effort. However, during the drilling project, the drill struck the storm sewer, which was only about 8 feet below the surface. Also, during the drilling project, it was discovered that a manhole had been moved without documentation.

Configuration changes arising out of construction, repairs, inspections, and alterations to the infrastructure in and around the Howard Street Tunnel were unreliable or non-existent, and the information exchange between CSX and the City of Baltimore was inadequate to ensure proper response and recovery in the event of an emergency. CSX railroad structures, portions of the MTA-MD's Central Light Rail, the Metro subway, and municipal and private utility lines and structures all coexist within a relatively compact area around the tunnel. Repairs and modifications to structures and utilities near critical infrastructure could have a significant effect on the tunnel's structural integrity and on

other nearby critical structures, including power substations and grids for the rail systems, water and gas lines, buildings, roadways, sidewalks, etc.

Tunnel plans showing the exact location of the tunnel under Howard Street and its relationship to MTA assets (CLR tracks and Metro tunnels) were not found until days later; the plans existed only in hard copy at the MTA engineering office.

Prepare for Hazardous Materials (Hazmat) Recovery

The potential environmental impact was the responsibility of the Maryland Department of the Environment's (MDE's) Emergency Response Division (ERD). ERD obtained the bill of lading provided by the CSX crew and contacted members of the South Baltimore Industrial Mutual Aid Plan (SBIMAP). Established in 1982 and largely funded by industry, SBIMAP is a voluntary consortium of manufacturers, emergency response personnel, Baltimore City environmental and emergency management personnel, and MDE. The consortium is focused on industry in the South Baltimore industrial area, but its general purpose is to plan for and respond to incidents in which hazardous materials and potential environmental harm are involved. SBIMAP conducts periodic drills and works with emergency responders to train, practice, and refine response to hazardous releases.

Member companies provided two chemists who quickly determined that there was no individual or combined danger from any of the chemicals involved in the derailment and subsequent fire. MDE advised Baltimore City Hazardous Materials (HazMat) Response Team of a potential hydrogen fluoride (HF) vapor hazard due to thermal degradation of fluorosilicic acid and identified specialized treatment needed for HF exposures. MDE also set up booms in the Inner Harbor to minimize contamination from chemicals seeping from the leaking rail cars.

MDE furthermore initiated air and water quality monitoring in order to detect leaks or discharges. Based upon the results of this monitoring, a determination was made that evacuating the downtown area would not be necessary. However, shelter-in-place plans were put into action on the decision of the Incident Commander, and sirens were sounded throughout the downtown area to notify residents.

Because of the pre-planning through SBIMAP for a hazardous materials release and its aftermath, the recovery phase in this area was facilitated. In fact, the issue was resolved before the fire was extinguished and other recovery efforts had yet to begin.

Critical Infrastructure Interdependencies

The loss of the communications pipe and the cables contained within the tunnel did not have a profound effect on recovery efforts in the Howard Street Tunnel incident. However, communications infrastructure loss of this type can have more widespread and lasting effects on recovery than one might anticipate.

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Within cities, communications lines concentrate in physical locations called carrier "hotels," otherwise known as telco or telecom hotels. They may be buildings, tunnels, viaducts, or other existing key structures. According to Kazys Varnelis (Spring 2005),

> the lasting economic effect (of the Baltimore tunnel fire), both locally and globally, might have been worse. Losing a major carrier hotel or a central switching station could result in the loss of all copper-wire and most cellular telephone service in a city, as well as the loss of 911 emergency services, Internet access, and most corporate networks. Given that many carrier hotels on the coasts are also key nodes in intercontinental telephone and data traffic, losing these structures could disrupt communications that we depend on worldwide.

Water in Critical Tunnels

Water in the Howard Street Tunnel was a common condition. It is not known how much of the water intrusion in the Howard Street Tunnel came from the July 2001 fire, the water main break, storm sewers, groundwater intrusion, runoff or any other source.

Wet conditions and water intrusion are not unique to the Howard Street Tunnel. *TCRP Synthesis 23: Inspection Policy and Procedures for Rail Transit Tunnels and Underground Structures* states the following:

> The number one problem affecting tunnels and underground structures is groundwater intrusion and the subsequent damage caused by the presence of tunnel leaks. This groundwater intrusion is responsible for more problems affecting a tunnel's concrete liners and steel reinforced concrete than all other tunnel structural problems combined.

TCRP Synthesis 23 also concluded:

> There was a clear preponderance of water intrusion-related tunnel defects. This conclusion comes as no surprise to those familiar with rail tunnel conditions and maintenance priorities. Water leakage, infiltration, corrosion, spalling, de-laminations, potential cracking, and siltation all indicate the intrusion of water, usually associated with chloride or calcium carbonate (from the deterioration of concrete). Keeping water out of tunnels, and adequately draining the water that intrudes into tunnels are perhaps the two most substantial issues reported by responding rail transit system inspection managers, and the most intractable problems for transit tunnel inspectors and maintenance crews.

Many rail tunnels have water intrusion of some kind, and some rail systems experience constant dampness in their tunnels. Groundwater intrusion and other seepage, the possibility of water main breaks, clogged drains, pump failure, and storm flow/flooding all make water a major source of threat and vulnerability for tunnels. These types of failures can be critical, resulting in derailments, collisions, and possible loss of life. Highway tunnels experience the same damage from wet conditions, and degradation to the roadway and tunnel integrity can occur. Hydrodemolition, or removal of concrete by high-pressure water is one outcome of any type of flood including water main breaks, storm surges from hurricanes, and flash flooding.

The high frequency of water intrusion in tunnels and the damage that can occur when prolonged water intrusion is not addressed suggests that preventing/mitigating water intrusion be a high priority in designing, engineering, constructing, inspecting, and

maintaining tunnels. When tunnels are in proximity to bodies of water and have the threat of breach and inundation, they should be considered high-risk installations. Even when no other alignment is possible, if the tunnel is a critical link, which most tunnels are, they must be inspected, maintained, and repaired on a more rigorous schedule than above-ground applications. Pumps should be reviewed and updates considered on a regular basis to reflect technological and mechanical improvements, with appropriate breakers to handle high-moisture situations, and reliable and robust back-up power should be in place for emergency operations.

Another issue is earthen dams, which are often privately built and owned and are not always brought to the attention of local jurisdictions. If they are in proximity to transportation assets and are in danger of failure in flooding events such as storms of 1%/year, ½%/year or 0.1%/year magnitude, without pre-planning, they may inundate assets since their existence was not known or considered.

Processes and Tools

Utilize Pre-Existing Relationships

Pre-planning consortiums, like SBIMAP, and establishing professional relationships in advance of an incident will greatly enhance recovery efforts. City management should continuously review and update plans, strategies, and standard operating procedure (SOP) tactics for response and recovery in tunnel incidents. All cities with a railroad industry should collaborate with the industry to be successful and comprehensive in response and recovery.

Understand Resilience and Redundancy

Ensure that critical infrastructure is analyzed to identify chokepoints and redundant systems (to the extent feasible) that can be used to compensate for a major transportation system disruption. Resilience of critical systems should be part of regional planning and redesign/rehabilitation of critical infrastructure. Rehabilitation of structures should include designing and building alternatives for transportation during the building and rehabilitation phases.

The importance of resilience means looking at interdependencies beyond just one facility or agency. Contemplation of resilience when considering running hazardous freight through the Howard Street Tunnel (which historically had not always carried freight), would have raised issues, including the proximity of the water main. In addition, as planning progressed over time, the light rail system, the Metro, and the communications assets were also placed in proximity to the hazardous cargo running through the tunnel.

Do Hazard and Risk Assessments

These essential evaluations must be done on all critical infrastructure to properly pre-plan for recovery operations. These evaluations should use an all-hazards approach; develop

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worst-case scenarios; and consider the impacts of loss and the time, money, and effort required to restore systems to operation at previous service levels. These assessments must be performed throughout the lifecycle of the critical infrastructure asset. In particular, they are needed whenever other assets are proposed in proximity to critical infrastructure, especially high-risk security assets such as military and intelligence installations, power and utilities, infrastructure for transportation and communications, and structures and locations where large numbers of people congregate for social, transit, or business purposes.

Plan Effective Information Sharing

Critical information is not critical until it is needed. This concept is simple, but information is not always available until well after recovery efforts have begun. Pre-planning for access to information, especially information that may not seem necessary for normal operation, will be critical. For instance, if an incident occurs in a tunnel adjacent to a building, it may be necessary to determine the floor plan and contents of privately owned property. This information may be critical to recovery, but it is probably not part of the emergency planning process for critical infrastructure access.

Pre-Position Equipment if Possible

Recovery efforts, especially debris removal, as in the case of the extrication of still burning rail cars from the Howard Street Tunnel with the cooperation of MTA and its specialized rail equipment, is one way to speed and ease recovery efforts, especially in the case of foreseen events. Even in unforeseen events, pre-planning using an all-hazards approach yields excellent strategies for dealing with events. Assuring that resources are inventoried and categorized, with information available to all agencies participating in recovery efforts, will facilitate pre-positioning for optimum recovery.

Put Emergency Contracts in Place Prior to Event

Effective recovery efforts require the pre-planning step of ensuring that emergency services contracts are in place for all-hazards events. In addition, access to a trust fund, such as the one used by the Maryland Department of Transportation for recovery efforts in the Howard Street event, will facilitate recovery efforts.

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2009 California Wildfire, Los Angeles, California

Event and Recovery Summary

Synopsis of Event

On the afternoon of August 26, 2009, at approximately 3:30 p.m., the Station Fire commenced. The fire was officially declared arson the same day. Four days later, on August 30th, two firefighters were killed, resulting in a homicide investigation. Twenty-two people were injured, over 160,000 acres or 250 square miles were affected, and nearly 200 structures were destroyed in the Station Fire, making it the 10th largest fire in modern California history and the largest fire in the recorded history of Angeles National Forest.

Station Fire Event Timeline

August 26, 2009, approximately 3:30pm: The Station Fire commences on Angeles Crest Highway. The cause of the blaze is declared arson. Los Angeles County Sheriff's Department begins a criminal investigation.

August 29–31, 2009: The fire expands to more than 80,000 acres within 3 days of starting, considered to be the most accelerated portion of expansion in the duration of the fire.

August 30, 2009: Los Angeles County firefighters Arnold Quinones and Tedmund Hall are killed in their Fire Department vehicle, turning the criminal investigation into a homicide investigation.

October 16, 2009: The Station Fire is officially declared contained, partially due to October rains.

The fire ravaged two Caltrans District 7 highways, affecting 40 miles of Angeles Crest Highway (SR-2) and 7 miles of San Gabriel Canyon Road (SR-39).

The fires in the Angeles National Forest continued to burn for almost 2 months and were officially contained on Friday, October 16, 2009. After containment, the initial priority was to clear two state highways, SR-2 and SR-30, in order for firefighters and other repair maintenance crews to gain access to fire-stricken areas.

Impact of Event on Critical Infrastructure

The fire damage to the highways and road systems included the destruction of thousands of wooden guardrail posts. Asphalt, berms, and drainage systems were damaged from the intense heat of the fire. Aluminum road signs were melted and vegetation was completely burned.

Caltrans had to replace incinerated transportation support structures including 4 miles of guardrails, drainage pipes, mile-marker posts, and hundreds of signs and sections of pavement. Caltrans authorized $12.5 million for three emergency contracts to commence immediately by outside contractors.

Almost a year later, these highway structures were not yet open to the public due to effects from massive mud slides enabled by the fire during and after containment.

Impact of Cascading Consequences

The complete burn off, with extensive burning and destruction of vegetation in the forest area where the rocky terrain is steep and unstable, meant that massive rock and mudslides could occur without warning. With winter coming, the El Niño effect accompanied by heavy rains could worsen the situation. According to Caltrans Damage Restoration Coordinator, Bill Varley, "When the rains come, there could be massive debris flows. All it takes is one storm to start flushing everything on the surface downward. You get an avalanche of mud, water, ash, fragments of wood, rocks, everything."

Erosion control measures were investigated including a new method called hydromulch, a water and fiber mulch mixture that is sprayed onto exposed soil to control erosion and help stabilize vulnerable slopes near the road. Caltrans had received permission from the National Forestry Service to use hydromulching for roadway protection in selective areas. It worked well, but the National Forestry Service did not permit all surfaces to be sprayed. The National Forestry Service had jurisdiction where the Caltrans teams sought to spray.

In the winter of 2010, Southern California experienced mudslides due to rains that were, according to the National Weather Service, the strongest to hit the region in 5 years.

Pre-Event Planning for Recovery

Emergency Processes Have Been Established in Advance

The California Governor's declaration of disaster can ease environmental requirements and other contracting requirements that can speed up the recovery process.

Pre-Event Recovery Planning Is Part of Hazard Mitigation Effort and Coop Activities

Recovery is integrated into other existing planning processes, such as hazard mitigation planning and COOP efforts. In addition, Caltrans has COOP engineers on staff who "understand infrastructure," i.e., who have designed and built transportation infrastructure. Their expertise provides the perspective to address infrastructure issues in both hazard mitigation and recovery planning.

Resources Are Identified and Pre-Positioned if Possible

Resources should be identified from all relevant sources, including volunteer organizations. Coordination with agencies such as the Water Department and the Department of Forestry was critical to providing recovery resources. Placement of

resources and identification of staging areas for resources were done in advance. In addition, debris removal plans were created and put in place prior to the event.

Contractors Have Been Identified in Advance

Recovery is expedited by having pre-identified and pre-qualified contractors. This allows emergency contracts to be implemented rapidly, even before funding is available.

Lessons for Recovery

Lessons from Previous Incidents Were Put in Practice

Knowledge gained from the San Diego County wildfires of 2007 and a post-fire mudslide near Independence, California, was used in pre-planning and preparedness for the 2009 Station Fire. Improvements were made in risk assessments and hazard mitigation practices; coordination amongst staff, contractors, and other agencies; and estimations of roadway closures.

Coordination among Multiple Agencies Is Critical

From a transportation perspective, critical coordination was necessary among multiple agencies including Caltrans, U.S. DOT, FHWA, the California Department of Forestry, the California Department of Fish and Game, and Los Angeles County First Responder Units. All entities worked well together in the early stages of recovery, but later it became clear that the organizations had different perspectives on the urgency and appropriate scope and pace of the recovery. These differences caused disagreements among organizations over how best to approach the recovery.

Expect the Unexpected

The threat of wildfires is a known hazard in California as are the risks associated with mudslides due to rains following wildfires. However, the combination of the severity of the 2009 Station Fire, which substantially impacted the terrain of the mountainous area it encompassed, and the anomalous storms that followed the fire, resulted in challenges for planning.

Identify Stakeholders and Their Interests

Being familiar with the needs of the multiple agencies and communities involved and understanding the dynamics between multijurisdictional entities can help address the conflicts and debates that can arise during an event. Establishing an interagency/intercounty working group before an event to coordinate planning and address implementation issues such as what procedures can be used and where—e.g., hydromulching—can improve the recovery process. Joint training exercises can be used to work through potential issues and plans before an event.

Plan for the Full Chain of Events

Understanding the potential cascading effects of an event is critical to recovery. Planning for the full chain of events—e.g., potential mudslides occurring after wildfires—will improve the effectiveness of the recovery process.

PROCESSES AND TOOLS

Standardized Assessment Process Used

Caltrans has established a Safety Assessment Program (SAP) to quickly produce damage assessments after an event. The program is based on the ATC-20 building assessment program developed for assessing damage after an earthquake. The program has been adapted to include highways and other key assets.

Prioritization Process in Place

Caltrans has adopted the National Highway System (NHS) classification system—strategic national highway network—as a key priority component in addition to the long-established Lifelines Identification and Asset Management system already in place. These three questions are typically answered:

1. Is it on the NHS?
2. What is the level of traffic?
3. Is there an alternate route?

Multiagency Working Group Has Been Established

A working group should be formed that is composed of key asset owners and stakeholders to coordinate incident planning and implementation. The group provides an opportunity to address conflicts over priorities and challenges related to jurisdiction. Having an existing forum can assist in resolving the debates about shared costs of recovery and responsibility for the cost of mitigation.

GIS Mapping Tools Are Used

Substantial GIS mapping is available to assist in recovery planning. Pre-event, it can help determine vulnerable areas and identify critical assets at risk. After an event, it can help identify and analyze damage to develop recovery plans. GIS maps provide an overall view of damage and recovery needs with location-specific information that includes severity of damage to buildings and infrastructure. After Katrina, FEMA produced high-resolution maps that showed the flood impacts from the storm.

Recovery Included in Existing Plans

The California State Emergency Plan includes a Recovery section that Caltrans helped to develop. The Caltrans Hazard Mitigation Plan includes all aspects of emergency management and recovery.

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MIDWEST FLOODING, 2008

EVENT AND RECOVERY SUMMARY

Synopsis of Event

In June 2008, much of the Midwestern United States received over 12 inches of rainfall as several storm systems sequentially impacted the region. The vast majority of the precipitation was channeled directly into lakes, rivers, and streams as runoff. Resulting stream flows reached historic highs across the Midwest, particularly in multiple areas of Iowa. Flooding lingered for weeks in many areas and broke historic records for flood levels.

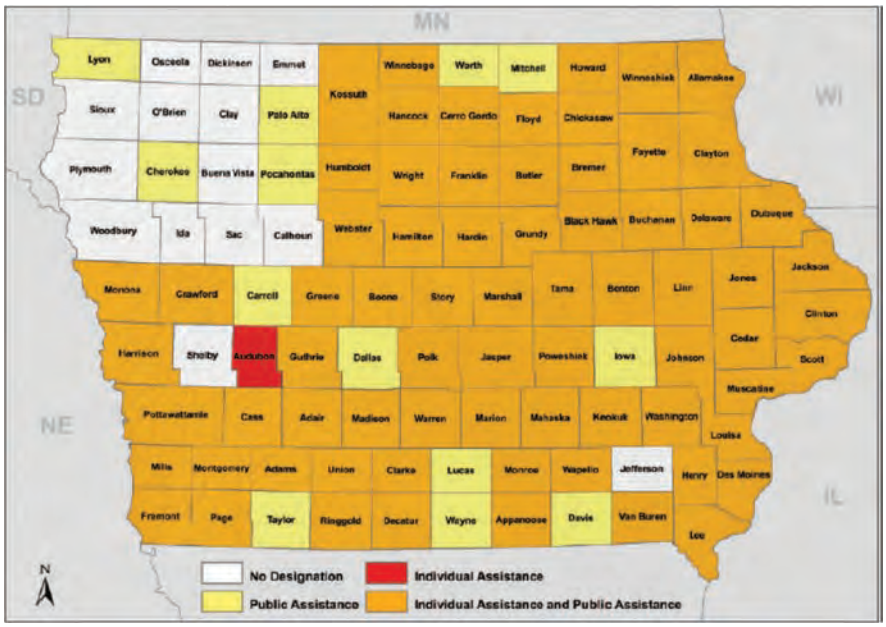
May–June 2008 Event Timeline

May 27, 2008: Presidential disaster is declared due to severe storms and tornadoes and increases from 4 counties to 85 counties.

Iowa Governor Chet Culver declares a state disaster for 85 counties.

June 2008: Iowa and the Midwest receive over 12 inches of rainfall via multiple storm systems.

A presidential disaster declaration was made in Iowa on May 27, 2008, for severe storms and tornadoes. It was updated and amended after the June flooding, increasing from 4 counties to 85 counties throughout the state (as shown below).



Impact of Event on Critical Infrastructure

On the state roadway network, 24 state roads, 20 highways including Interstates 80 and 380, and more than 1,000 secondary roads were closed at various points during the course of the flooding. Damages accrued to public transportation infrastructure were approximately $53 million.

Recovery of Critical Infrastructure

The Iowa DOT was the only agency in Iowa that had the staff and equipment needed for disaster response and recovery. Initial disaster recovery efforts completed by the Iowa DOT involved debris removal from roadways. During this period, Iowa DOT staff simultaneously initiated emergency repairs to federal-aid highways, as a part of the FHWA emergency relief program, to restore essential traffic, minimize the extent of damage, and protect the remaining facilities. The Iowa DOT submitted all FHWA emergency repair projects and funding requests within 60 days of the flooding event.

After emergency repair projects were submitted, the Iowa DOT began the process of addressing permanent repair needs to federal-aid highways within the state. Permanent repairs are those repairs undertaken to restore the highway to its pre-disaster condition and must have prior FHWA approval and authorization unless done as part of the emergency repairs.

The Iowa DOT not only addressed the needs on its own system of state and federal highways, but also oversaw the submittal of close to 300 projects from state, county, and city governments for locally owned or managed roadways.

The initial disaster recovery efforts, which mostly involved debris removal, lasted an average of 4 weeks. The FHWA emergency repairs to Iowa DOT roads lasted 1 to 3 months. According to the Iowa DOT office, no major delays or unexpected obstacles were experienced in the recovery process

Pre-Event Planning for Recovery

Use of Integrated Planning Process

The Iowa DOT takes an all-hazards approach to emergency management, which includes recovery as one of its four phases—preparedness, mitigation, response, and recovery. Employee training, staff development, and developing FEMA resource management capabilities are considered comprehensive, allowing individuals to contribute to all disaster phases, rather than focusing on any one phase, i.e., solely recovery.

Iowa has a State Recovery Plan that includes a Transportation Appendix that details the roles, responsibilities, and framework for post-disaster transportation recovery.

Advance Coordination with the Iowa Homeland Security and Emergency Management Division (HSEMD) and the State Emergency Operating Center (SEOC) in Place

Local management agencies request resources and assistance from the SEOC, which are then assigned to local state agencies after review. Iowa DOT is typically assigned debris-removal missions.

Iowa DOT also engages in executive-level decision-making in recovery efforts such as defining and committing resources to flood-damaged areas throughout the state (both personnel and equipment) and working with other state agencies to coordinate disaster response and recovery efforts. The Iowa DOT Bridges and Structures Office and the Office of Design were utilized to provide bridge and road plans, as well as expert advice on the conditions of structures (bridges, culverts, wing walls, etc.) impacted by the flooding.

Established Relationships and Support Roles with Federal Agencies

After significant disaster events, the Iowa DOT works closely with multiple federal agencies as a part of the recovery process for their transportation infrastructure. FEMA public assistance officers are critical in calculating damage amounts to infrastructure, which in turn fund the disaster recovery. These FEMA public assistance funds can be used to repair roads, bridges, and associated facilities, e.g., auxiliary structures, lighting, and signage. Members of the Iowa DOT serve as project officers for FEMA, with the responsibility of assisting public entities such as cities and counties in gathering information and completing worksheets essential to receiving FEMA recovery funding.

The Iowa DOT also functions as the coordinator for the FHWA emergency relief program and takes on the responsibility for processing Detailed Damage Inspection Reports (DDIRs). DDIRs are forms used to document the cost estimates for emergency repairs to federal-aid highways after a significant disaster occurs. The DDIR is written to determine eligibility, scope, and preliminary cost estimates for the work, which the FHWA uses to support their request for emergency repair funding. The projects that were submitted to FHWA during the 2008 flooding disaster came from the Iowa DOT, Iowa counties and cities, the Iowa Department of Natural Resources (Iowa DNR), and railroad crossing systems within the state of Iowa. All of these projects were required to be submitted in the form of a DDIR.

Critical Design and Infrastructure Records Have Been Compiled and Are Easily Accessed

Many roadway and bridge design plans, shop drawings, and other infrastructure record documents are available electronically on a 24-hour basis, with plans to import older, paper bridge and road designs into the Iowa DOT's electronic record management system (ERMS).

Lessons for Recovery

Innovative State Funding Approaches Used

Based on experiences from previous floods, a temporary state agency, the Rebuild Iowa Office (RIO), was created. RIO was engaged in community and regional recovery planning; disaster recovery case management coordination; communications and public outreach; and economic, environmental, housing, and infrastructure recovery.

Recognizing the need to repair all of the damaged roads, bridges, and other transportation infrastructure within the state, plans were made to fund these repairs through grants from U.S. DOT, FEMA, and I-Jobs bonding funds. Iowa's Governor developed the I-Jobs initiative, a program focused on strengthening the state's economy and rebuilding local infrastructure, following the 2008 storms. I-JOBS was a $875 million state infrastructure modernization program designed to support or retain jobs, rebuild communities impacted by the 2008 floods, and promote long-term economic growth. Of the total, $118.5 million was used for competitive disaster recovery grants and $46.5 million was used for targeted disaster rebuilding.

Additional funding for infrastructure projects was made available through the Community Disaster Grant Program (CDGP), which was created in February 2009 by the Governor. The CDGP program is a $22 million disaster relief program that provides grants of $2,000 or more to cities and counties to projects that are not being otherwise funded (by federal or non-federal sources).

Improve Coordination with State And Local Governments and Federal Agencies

The Iowa DOT had in place electronic processes and tools to help streamline recovery efforts, but recognized the need to make changes to better align with federal agency requirements such as FHWA reporting requirements. The FHWA ER program requires that communities complete detailed damage inspection reports for (DDIRs) for reimbursement. The Iowa DOT is creating a software program that allows all community members to electronically document damages in the DDIR software. Once the damage data are entered, the DDIR program will automatically generate emails to different state offices that may be interested in taking on the project. This program will help automate the workflow by allowing state agencies to view damage reports almost as soon as they are entered by community members.

Need for Additional Staffing and Training for Emergencies

Iowa DOT realized a need for additional staffing and training at the State Emergency Operations Center (SEOC) and at the Iowa DOT headquarters in Ames. The Iowa DOT is planning to provide additional training on the FHWA DDIR process and for Iowa DOT public assistance project officers.

Processes and Tools

Electronic Record Management System (ERMS) for Critical Documents

With the large number of damaged roads, it was imperative for the Iowa DOT to effectively distribute critical information such as computer-aided design and drafting (CADD) files to personnel assisting with the recovery processes at the damaged sites. In order to accommodate the need for distributing pertinent information that could help decrease recovery time, the Iowa DOT has implemented the ERMS.

The ERMS electronically stores and organizes 1.2 million CADD records representing over 6 million pages of information. The decreased personnel productivity from the time-consuming tasks of paper handling and the inefficient process for storing, routing, and approving documents are removed from the recovery work flow process, allowing the Iowa DOT personnel to focus their resources on other tasks. The files stored in the ERMS are data encrypted and are open server/browser based—they do not require any proprietary workstation software.

Records Management System (RMS) Used to Collected Reimbursement Information

The Iowa DOT has implemented a record management system (RMS), which is an electronic tool that retains information regarding completed jobs, number of employees on a job, equipment usage, and expenses. This information is entered and stored through electronically submitted timesheets, expense reports, and equipment management reports. While the RMS is primarily used as a data-collection tool, it also allows the Iowa DOT to catch information such as materials, labor, and equipment for reimbursement of federal aid programs such as the FEMA public assistance (PA) program and the FHWA emergency repair and permanent repair programs. Once a day, Iowa DOT staff completes the RMS entries, and a summary is produced. These daily summaries are then reconciled into a pay period summary, which is sent directly to governmental agencies that are providing funding to the Iowa DOT.

The Iowa DOT is currently in the process of updating the RMS in order to automate the reimbursement process from governmental agencies. By instantaneously sending payment reports to governmental agencies through the RMS, the Iowa DOT can ultimately reduce the recovery process time.

Enhanced Use of GIS

To implement enhanced use of GIS in conjunction with improved system tracking, the Iowa DOT's Operations Support Center will provide a 24/7 capability to provide better and more current information. This enhanced information will be communicated with Iowa DOT partners.

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ASSET MANAGEMENT SYSTEMS

In this case study, the research team explored the use of asset management systems (AMS) as tools for resource allocation and performance measurement for managers of transportation infrastructure and the application of AMS for purposes of emergency management and disaster recovery. Questions considered by the research team include the following:

- What are transportation AMS?
- How are AMS currently deployed by state DOTs?
- Could AMS be leveraged as tools for pre-event recovery planning?

WHAT ARE TRANSPORTATION ASSET MANAGEMENT SYSTEMS?

The Midwest Regional University Transportation Center has one of the more concise and clear definitions of asset management:

> Simply bringing relevant data and analytic tools together with systematic implementation processes to ensure that the defined goals of the system are attained as efficiently as possible.

AMS are data-driven systems used by capital asset owners to monitor the condition and use of their assets and to make quantitative, alternatives-based decisions about how to invest resources in the maintenance and expansion of those assets. The earliest transportation AMS were applied to pavement conditions on roadways. These systems began as manual processes for chronicling the construction media and repair history of a roadway to assist in scheduling repairs and resurfacing. As computers became more pervasive and powerful, the amount of input that could be tracked became more complex (including weather and use levels and their impact on various elements of the asset). Increased processing power made it possible to apply AMS to more complex assets like bridges and facilities. Over the past two decades, transportation asset owners facing aging infrastructure, restrictions on public resources, and demands for investment accountability, have increasingly turned to policy- and measurement-driven AMS to

Timeline of the Modern Asset Management Program

1991 – Intermodal Surface Transportation Efficiency Act (ISTEA) required statewide transportation plans and addressed asset management and performance measures.

1994 – Executive Order 12983 required systematic benefit/cost analysis for federal infrastructure.

1994 – Government Accounting Standard Board (GASB) Concept Statement directed government agencies to establish and communicate goals and objectives and set measurable targets.

1998 – AASHTO adopted asset management as a strategic initiative and formed a task force to develop and implement a *Strategic Plan for Transportation Asset Management*.

1999 - GASB Statement 34 required more rigorous financial reporting from state and local governments. Also, recommended that capital assets be rigorously depreciated unless an asset management or maintenance and preservation plan is in place.

1999 – FHWA Office of Asset Management published the Asset Management Primer.

maintain their assets, justify their resource requests, explore the economic trade-off of investment alternatives over time, and improve the experience of the end user. *NCHRP Report 551* identified the core principles of a comprehensive system for assets management as follows:

- **Policy-driven**—Resource allocation decisions are based on a well-defined set of policy goals and objectives.
- **Performance-based**—Policy objectives are translated into system performance measures that are used for both day-to-day and strategic management.
- **Analysis of Options and Tradeoffs**—Decisions on how to allocate funds within and across different types of investments (e.g., preventive maintenance versus rehabilitation, pavements versus bridges) are based on an analysis of how different allocations will impact achievement of relevant policy objectives.
- **Decisions Based on Quality Information**—The merits of different options with respect to an agency's policy goals are evaluated using credible and current data.
- **Monitoring Provides Clear Accountability and Feedback**—Performance results are monitored and reported for both impacts and effectiveness.

These principles represent an idealized comprehensive system. The reality is, although AMS are increasingly embraced by state DOTs and other asset owners, the degree of their implementation varies widely.

How Are Asset Management Systems Currently Deployed by State DOTs?

Most state DOTs now have some form of asset inventory and preservation programs to meet the federal funding and reporting guidelines, but due to funding, data, other resources, or political limitations, many of these programs are underdeveloped and not strategically deployed. Although most AMS are at least nominally driven by statewide, long-range planning processes and the performance measures identified by these processes, the level of commitment to utilizing AMS for decision making and performance evaluation varies considerably.

A survey of state DOTs was conducted for this case study to further identify their structures and viability of AMS as emergency recovery tools. The table that follows provides a comparative overview of the AMS of the transportation agencies studied—Michigan DOT (MDOT), Montana DOT (MDT), Ohio DOT (ODOT), and Vermont Agency of Transportation (VTrans). These states were selected for this overview because of the relative maturity of their AMS. These states have their AMS integrated into their strategic planning process and either have a performance measurement process in place or in development—traits that provide a solid framework for testing the idea of leveraging AMS for pre-disaster planning and recovery.

Survey of Selected States with Asset Management Systems

	Michigan	Montana	Ohio	Vermont
AMS Program	Transportation Management System (TMS). Integral decision support tool to feed a comprehensive project prioritization process and to provide a clear link showing how proposed projects and proposed use of funds support the State Long Range Plan and the Long Range Plans of TMAs, MPOs, and other agencies within Michigan.	Performance Programming Process (P3). Ensures the best system-wide investment decisions are made given: (1) Overall direction from customers, (2) Availability of resources, and (3) System performance monitored over time.	ODOT uses asset management to identify, evaluate and maintain its transportation assets in a steady-state manner. Annual condition assessments are reviewed and these trends are used to predict future asset conditions. The projected conditions are compared to adequacy thresholds to identify lane miles or assets that are deemed deficient. Performance measures are used to monitor the effectiveness of the asset management process and to adjust management strategies or resource levels.	VTrans uses AMS and performance measures to implement and evaluate four key goals: safety, preservation, excellence, and planning.
Managing Agency	Michigan Department of Transportation (MDOT)	Montana Department of Transportation (MDT)	Ohio Department of Transportation (ODOT)	Vermont Agency of Transportation (VTrans)
Origin	Act 51 of the State of Michigan Public Acts of 1951 (initially pavement management), revised July 25, 1997, and again by Public Act 199 of 2002.	Identified as part of TRANPLAN 21 (1994) – State Planning Document.	Developed through the long-range, strategic-planning process	Sections 24 and 25 of Act no. 64 (2001) required VTrans to develop an asset management system, including a performance-driven and decision-making process for maintaining, upgrading, and operating transportation assets cost-effectively.

	Michigan	Montana	Ohio	Vermont
Reason for Initiating	Justification for funding, system preservation, and accountability.	Improve pavement condition, prioritize funding allocation, improve customer experience, satisfaction, and accountability.	Eliminate transportation system deficiencies statewide and then maintain over time, including accountability.	Justification for funding, efficient allocation of resources, preservation of aging infrastructure.
Funding Source	Michigan's House Bill No. 5396 provides for annual appropriations to support and implement a statewide asset management program.	Part of the MDT budget.	Part of the ODOT planning budget.	Part of VTrans planning budget.
Participating Asset Types	Roads, Bridges, Park-and-Ride Lots, Vehicles, Rail Lines, Railroad Bridges, Railroad Crossings, Airports, Planes, and other Facilities and Assets.	Pavement and Bridges.	Pavement, Bridges, and Highway Maintenance.	Pavement, Bridges, Maintenance, Vehicles and Equipment, and Aviation. VTrans is developing a Rail Policy Plan in which rail operators are required to evaluate tracks and beds per lease terms.
Multi-Agency Coordination	The Transportation Asset Management Committee includes agencies that own and manage roads and bridges.	Some coordination with MPOs and local road owners.	Some coordination with MPOs and local road owners.	Some coordination with MPOs and local road owners.
Evaluation System	Pavement Surface and Evaluation Rating (PASER) Bridge Condition Forecasting System (BCFS).	Ride Index – perceived quality (smoothness) of ride. National Bridge Inventory Condition Assessment.	Organizational Performance Indicators (OPIs), integrated with Ellis Project tracking and funding application.	dTIMS for pavement. PONTIS for bridges (working to fully utilize). MATS (Maintenance Activity Tracking System).
Performance Measures and Evaluation Tools	Yes	Currently in development.	Yes	Yes - 33 strategic performance measures related to condition of underlying asset, or measure a service provided to users.

	Michigan	Montana	Ohio	Vermont
Identify and Evaluate Project Alternatives	Yes	Yes	Yes	Yes
System Integration	TMS is a single management system with six subsystems: Bridge, Congestion, Intermodal, Pavement, Public Transportation, and Safety. This allows the TMS to include a common shared database, a common set of decision support tools and functionality, and the use of a robust and consistent user interface. Data collected, processed, and maintained at the working levels are stored using an enterprise database management system.	No	OPI is applied across assets	Some
Integrated into Master Planning	Yes - AMS is a part of e-Michigan Transportation Policy Plan, State Long-Range Plan, agency business plans as well as program-specific strategies.	Yes - P3 is a product of the master planning process and is an element of the STIP and TIP.	Yes - AMS is an element of strategic and business planning as well as the STIP and TIP process.	Yes – AMS is integrated into long-range strategic planning as well as STIP and TIP process.

	Michigan	Montana	Ohio	Vermont
Linked to Resource Allocation and Decision Making	Yes	P3 "guides" the project nomination process and the P3 performance measures are considered during project selection.	Yes, priority funding recommendations are made based on OPI performance measures and strategic goals.	Yes
Public Input and Reporting	Internet Site, Newsletter, Michigan Transportation Facts & Figures, and STIP and TIP Process.	Limited to the STIP and TIP process and long-range planning. Progress Reporting is under development.	AMS is an element of the Governor's Jobs and Progress Plan.	Limited to STIP and TIP process and long-range planning.
Does Managing Agency have an Emergency Planning or Incident Response Group?	Yes	Yes	No	No
Is the AMS linked to Emergency Planning or Incident Response?	No	No	No	No

The results of the state DOT survey reflect the original assumptions that AMS are applied to varying degrees, are inconsistently integrated into DOT strategic planning, and are still in the expansion and development phases. On the other hand, these examples do show that the state DOTs surveyed collect and analyze a large amount of complex and potentially useful data. DOTs are expanding their AMS programs and integrating AMS analysis into their planning and investment policy and lifecycle management.

The survey, although not exhaustive, did not identify formal integration between emergency management operations and the AMS process. Interviewees did identify some informal or personal connections between the groups responsible for maintaining the AMS and the emergency management entities. Within the Michigan DOT, for example, the administrator of the Safety and Security group has a strong personal relationship with the administrator of the AMS operations group. This is manifest in semi-regular conversations and occasional data or information requests from the Safety and Security group during emergency response or planning activities. Although there are no plans to formalize or deepen this relationship, interviewees acknowledged the potential benefits to improved and standardized coordination.

Could Asset Management Systems Be Used for Pre-Event Recovery Planning?

None of the AMS surveyed are currently connected to pre-disaster planning and recovery, but the logical link between the two does exist and has been indirectly identified and explored by previous TRB reports (see below). These prior findings begin to demonstrate the rationale for AMS-Emergency Management process integration.

NCHRP Report 551: Performance Measures and Targets for Transportation Asset Management (2006) investigates the current state of practice for the integration of performance measurements in AMS. The report establishes categories of performance measurements, one of which is preservation. The applied definition of preservation measurement includes actions required to maintain the asset in a condition of good repair during emergency situations. Preservation is a founding principle of asset management and by prioritizing the preservation of infrastructure and a state of good repair, asset owners can reduce the chance that an incident will cripple or destroy infrastructure. The natural progression of system preservation is the identification and application of specific mitigation that would increase the likelihood that an asset would withstand natural and manmade events.

NCHRP 525: Surface Transportation Security—Volume 15: Costing Asset Protection: An All Hazards Guide for Transportation Agencies (CAPTA) (2009) provides a guide for developing system-wide budget estimates for all hazards approach mitigation rooted in the National Incident Management System. It uses asset type and profiles to identify recommended countermeasures and accompanying costs. States that already employ comprehensive and fully integrated AMS will have already compiled the necessary information to execute the evaluation program.

NCHRP Report 525: Surface Transportation Security—Volume 16: A Guide to Emergency Response Planning at State Transportation Agencies (2010) identifies the need for improving

construction and maintenance methods to mitigate risk of failure during emergency events. AMS would be a natural tool for implementing this goal.

The guidelines established by these reports begin to suggest the application of AMS primarily in the response phase of emergency management. AMS information provides a natural foundation for identifying and activating resources (vehicles, equipment, and materials) in an immediate response situation.

Recovery phase application for AMS may be a bit less obvious, but could prove more effective in restoration of service in the long run. The inventories of key infrastructure, including roadway and rail segments, bridges and other structures, signage and traffic control devices, communication systems, buildings, and other fixed assets could provide rich and malleable data sets for recovery planners and policy makers to support accelerated recovery decision making. AMS could be applied directly to the following recovery activities:

- Identifying and prioritizing critical infrastructure.
- Developing an accurate snapshot of the "before" condition.
- Facilitating the development of re-procurement guidelines and contracts.
- Identifying potential resilience and lifecycle improvements that could be made to improve the asset during recovery.

The logical next step to this line of thinking is the expansion of AMS to include planned investments, expansions, and reconstruction of the included assets. This extra layer of "improved" data could be then applied to ensure that recovery efforts consider providing improved service and/or resilience to the reconstructed or restored assets.

CONCLUSIONS

AMS have current and potential value in evaluating and improving asset resiliency.

1. **Explicit integration of emergency response practices with the infrastructure planning and operation processes of AMS is a natural next step**. AMS are already used to reduce the likelihood of asset failure by systematically and efficiently evaluating the asset elements and making lifecycle investments accordingly.

2. **State DOT and emergency management agencies could develop standardized communication, data development, and planning processes to facilitate data and information sharing and integration**. This could lead to information overlays that match identified hazards with assets that would likely be affected; the ability to incorporate hazard and threat information into AMS evaluation systems; and the prioritization of preservation and mitigation investments.

3. **AMS could be expanded to incorporate pre-disaster mitigation and recovery as performance measurements**, providing an iterative and accountable system for improving the resiliency of transportation assets.

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APPENDIX C: DAMAGE ASSESSMENT AND PRE-EVENT RECOVERY PLANNING

Disaster assessment includes both determining the extent of infrastructure damage and assessing the viability of continued use of the site. Damage can range from some minor damage that can be immediately fixed with local resources to more extensive damage that requires substantial resources, including government resources, and years of time. Research has found that early assessment decisions set the tone for the efficiency of the recovery.

One of the earliest challenges to recovery is understanding the extent of the damage along with what is required for repair. Multiple organizations—from state and local DOTs to federal regulatory agencies—are likely to be involved in damage assessment, and each may have their own methodology and time-frame requirements. In addition, with numerous agencies involved, it becomes difficult to determine instances of duplication or omission. In some states, such as Wisconsin, the DOT serves as the coordinating agency for assessing infrastructure damages in the state. Becoming familiar with the assessment process and who is responsible for what provides a head start on the recovery process.

Although damage assessments can only be conducted after an event, systems and teams to support the recovery process can be created in advance. Establishing a standardized damage assessment classification system with supporting tools such as damage assessment forms can improve the quality and speed of the information obtained after the event. Standardized procedures and forms for damage assessments facilitate common understanding of the extent of damages and therefore facilitate contracting of repairs and reconstruction work to be performed. Case studies revealed this commonality lacking in the aftermath of the California wildfires and, as a result, the sense of urgency, scope, and pace was not the same across the organizations involved in the effort. On the other hand, as a best practice, Iowa DOT functions as the coordinator for the FHWA emergency relief program and processes the Detailed Damage Inspection Reports (DDIRs). The DDIRs are used to document cost estimates for emergency repairs and subsequently used to determine the eligibility, scope, and cost estimate for work, which the FHWA uses to support their request for emergency repair funding.

Identifying the damage assessment team in advance can ensure that the team contains the diversity of expertise and experience required and provides time for training on assessment methods and the damage classification system being used.

Key Assessment Functions	Pre-Event Actions
Rapid Assessment	• Identify lead state agency conducting/coordinating assessments • Become familiar with damage assessment process • Identify rapid assessment process • Identify and train team on rapid assessment methods
Preliminary Damage Assessment	• Learn who is responsible for assessments of transportation infrastructure • Establish standardized damage classification system • Identify and train team on classification system
Site Assessment	• Identify rebuild vs. relocate criteria. Consider whether re-siting to a location of reduced risk is an option. • Identify potential alternate sites for relocation and prepare/project cost estimates for possible land acquisition.

Damage Assessment Tools and Resources

Tools/Resources	Description and Web Link
iCat Storm Damage Estimator	iCat provides easy access to historical hurricane damage information. This interactive resource is a comprehensive, searchable interface to find damage estimates for all major storms in the United States from 1900 to the present day. The website encompasses a video explainer of how to use the site, including the extensive searchable methods available. The website includes sorting searches by storm year, name, place of landfall, category, as well as quick searches. Options for views include satellite, map, terrain, and Google earth, as well as map tools for selecting specific areas to show what storms occurred in any particular area. Searches can be bookmarked, and there is an option for exporting data and sharing from the estimator via email, print, Google Earth or in a spreadsheet file. *http://www.icatdamageestimator.com/*
FEMA Map Service Center	FEMA provides map information for a variety of users affected by floods, including homeowners and renters, real estate and flood determination agents, insurance agents, engineers and surveyors, and federal and exempt customers. There are flood maps, databases, map viewers, documents, and publications providing comprehensive information. Further aspects of the site include FEMA-issued flood maps available for purchase, definitions of FEMA flood zone designations, and information about FIRMettes, a full-scale section of a FEMA Flood Insurance Rate Map (FIRM) that users can create and print at no charge. *http://msc.fema.gov/webapp/wcs/stores/servlet/FemaWelcomeView?storeId=10001&catalogId=10001&langId=-1*

Information Tools to Improve Post-Earthquake Prioritization of Bridge Inspections	WSDOT tools and procedures to estimate the likelihood of slight (or greater) bridge damage based on the intensity of earthquake shaking (obtained from ShakeMaps) and on each bridge's location, year of construction, and bridge type and information contained in HAZUS software for predicting the lowest level of damage. *http://www.wsdot.wa.gov/Research/Reports/600/602.1.htm*
Safety Assessment Program (SAP)	California Emergency Management Program for registered professionals—licensed engineers, architects, geologists, and building inspectors trained to assess infrastructure for rapid damage assessment. *www.calema.ca.gov/Recovery/Documents/SAPGuideline.pdf*
ASCE Post-Disaster Assessment Manual	The ASCE Post-Disaster Assessment Manual provides general guidance for the formation and operation of ASCE post-disaster assessment teams (assessment team or team).The primary purpose of ASCE post-disaster assessments is to evaluate the behavior of various engineered facilities under extreme conditions and to learn from the behaviors observed. The goal of these assessments is to document lessons learned regarding the causes of failures, restoration efforts, restoration times, and success stories. The document addresses the process for making the decision to launch an assessment as well as outlining the overall purpose, funding, and operation of the team effort so that assessment teams can be assembled, assessments conducted, and findings reported in a timely manner. *http://www.nehrp.gov/pdf/ASCEPost-DisasterManual.pdf*
Safety Evaluation of Buildings After Wind Storms and Floods	The ATC-45 Field Manual provides guidelines and procedures to determine whether damaged or potentially damaged buildings are safe for use after wind storms or floods, or if entry should be restricted or prohibited. Formatted as an easy-to-use pocket guide, the Manual is intended to be used by structural engineers, building inspectors, and others involved in post-disaster building safety assessments. Advice is provided on evaluating structural, geotechnical, and nonstructural risks. Also included are procedures for Rapid Safety Evaluation, procedures for Detailed Safety Evaluation, information on how to deal with owners and occupants of damaged buildings, information on field safety for those making damage assessments, and example applications of the procedures. *https://www.atcouncil.org/Postdisaster-Safety-Evaluation-of-Buildings/Field-Manual-Safety-Evaluation-of-Buildings-after-Wind-Storms-and-Floods/flypage.tpl.html*

Post Earthquake Damage and Safety Evaluation of Buildings	THE ATC-20 product series contains guidelines and related materials for post-earthquake evaluation and repair of damaged buildings. The series is offered for sale on the Applied Technology Council (ATC) website, and includes all products in the ATC-20 Series and reports prepared under the ATC-43 project. Subjects in the ATC-20 series include basic procedure manuals, a field manual, case studies, a training slide set and a tech brief. Documents prepared under the ATC-43 project provide guidance on in-depth engineering evaluation and repair of earthquake-damaged mason-wall buildings and concrete-wall buildings (FEMA 306, FEMA 307, FEMA 308), which are collectively available on the ATC-43 CD. *https://www.atcouncil.org/vmchk/Postearthquake-Damage-and-Safety-Evaluation-of-Buildings/View-all-products.html*
Evaluation of Earthquake-Damaged Concrete and Masonry Wall Buildings, Basic Procedures Manual (FEMA 306) **Evaluation of Earthquake-Damaged Concrete and Masonry Wall Buildings, Technical Resources (FEMA 307)**	FEMA 306 was developed for and is focused on assessment and repair of earthquake-damaged buildings. The document provides practical criteria and guidance for buildings consisting of concrete or masonry bearing walls and frames with concrete or masonry infill panels. *http://www.fema.gov/library/viewRecord.do?id=1651* This document provides background and theoretical information to be used in conjunction with FEMA 306. Analytical and experimental findings are included, as well as information on the Component Damage Classification Guides. *http://www.fema.gov/library/viewRecord.do?id=1652*
Recommended Post Earthquake Evaluation and Repair Criteria for Welded Steel Moment-Frame Buildings (FEMA 352)	This report provides recommendations for performing inspections to detect damage in steel moment-frame buildings following an earthquake; evaluating the damaged buildings' safety in a post-earthquake environment; and repairing damaged buildings. Chapters cover inspection and classification of damage; preliminary post-earthquake assessment; detailed post-earthquake evaluations; and post-earthquake repair. The appendices include procedures for performance evaluation; sample placards that may be used to post buildings following preliminary post-earthquake evaluations; and sample inspection forms that may be used to record damage detected in beam-column connections as part of a detailed post-earthquake inspection program. *http://www.fema.gov/plan/prevent/earthquake/pdf/fema-352.pdf*
Post-Earthquake Investigation Field Manual for the State of Kentucky	The Manual provides a rapid and efficient method of inspecting bridge structures after an earthquake. Primary users are intended to be first-line transportation personnel who initially reach the bridge sites. *http://www.ktc.uky.edu/Reports/KTC_06_30_SPR_234_01_1F.pdf*

Checklist for Tornado/Hurricane Damaged Structure Inspection	After a structure has been damaged during any of the wind storms—tornado, hurricane, or high winds—this describes the damage signs that should be noted for a wood frame structure (exterior and interior), steel frame or load bearing walls, or concrete frame or slab. From AIA. http://www.aia.org/about/initiatives/AIAS075274?dvid=&recspec=AIAS075274 Related damage assessment worksheet available: *http://www.aia.org/aiaucmp/groups/aia/documents/pdf/aias077907.pdf*
Quick Rapid Post-Earthquake Building Assessment	This work presents two single and direct methods designed for post-earthquake building inspections and safety classifications in small-to-medium size towns stricken by a damaging earthquake. The first Post-Earthquake Building Safety Assessment (PEBSA) method is an easy way to achieve general and approximated initial information on damage distribution, and to detect heavily damaged and unsafe constructions (4 and 5 damage degree in EMS scale). These early data are necessary to emergency assistance, local disaster statements, external aid requests, and for organizing rapid building inspections. The second method, named Rapid-PEBSA, follows conventional approaches for post-earthquake safety inspections in seismic prone countries (USA, Japan, Italy). *http://www.narpimed.org/wp-content/uploads/Paper-3-post-EQ.pdf*
FHWA Detailed Damage Inspection Report (DDIR) Form	FHWA standard Detailed Damage Inspection Report (DDIR) form FHWA-1547 is available online. *http://www.fhwa.dot.gov/reports/erm/fhwa1547.pdf*

APPENDIX D: DECONTAMINATION TECHNIQUES

An incident involving the dissemination of chemical, biological, or radiological (CBR) threat agents that affects the infrastructure of a transportation system will result in significant disruption of services and could have catastrophic economic and other impacts not only to the local region, but also potentially to the nation. CBR incidents involve unique challenges that will likely require significant operational adjustments by transportation agencies to ensure a rapid return to service and an acceptable remediation.

Pre-event planning and preparedness were found to be essential to minimize the operational and financial impacts to transit services. The Response and Recovery Program in the Livermore Nonproliferation, Homeland, and International Security Directorate has been conducting research on the requirements for the decontamination of transportation facilities. The research has found that having a restoration plan vetted and facility personnel trained substantially reduces the overall time for a restoration operation.

Crisis Management		Consequence Management			
Response Activities		Restoration Activities			Recovery Activities
Notification	First Response	Characterization	Remediation/ Cleanup	Clearance	Reoccupancy
Receive and assess information Identify suspect release sites Relay key information and potential risk to appropriate agencies	HAZMAT and emergency actions Forensic investigation Public health actions Screening sampling Determine agent type, concentration, and viability Risk communication	Detailed characterization of biological agent Characterization of affected site Site containment Continue risk communication Characterization/ environmental sampling and analysis Initial risk assessment Clearance goals	Decontamination strategy Remediation action plan Worker health and safety Site preparation Source reduction Waste disposal Decontamination of sites and/or items Decontamination verification	Clearance sampling and analysis Clearance decision	Renovation Longer-term environmental and public health monitoring Reoccupation decision

The Livermore–Sandia project identified a set of activities for restoring a contaminated facility following a bioterrorist attack.

Absent an explosion or other obvious overt release, recognition that a CBR incident has occurred may take hours to days depending upon the specific threat agent, the circumstances of the release, and the response time of CBR monitoring equipment, if any is present. In particular, biological agents typically have latency periods of several days before exposed victims first develop diagnosable symptoms, and it may be even longer before a transit facility is identified as being contaminated. Chemical agents may produce recognizable symptoms within minutes to

hours. Although victims exposed to radiological agents may not produce symptoms for extended periods, some radiological agents are more readily detected with commonly available devices. Once a CBR incident is recognized, prompt actions need to be implemented to minimize further exposure (such as victim response and facility evacuation) and the spread of contamination (such as shutting down and by-passing impacted stations, shutting down ventilation systems, installing containment barriers, establishing perimeter security to deny unauthorized access, and isolating contaminated rolling stock).

Rapid activation of an Incident Command System (ICS) with qualified local personnel will be critical to achieving a rapid return to service. Understanding the roles and responsibilities and the milestones for transitions of authority within the ICS will contribute to efficient incident recovery operations. ICS plans and processes should be formalized in pre-disaster phases, before an event occurs to support rapid and efficient mobilization. Speedy access to subject matter experts (CBR agents, sampling and analyses, risk assessment, and decontamination technicians and technologies) and qualified specialty contractors will expedite the recovery operations. CBR assistance from federal resources may not be immediately available, and local authorities should plan to utilize their own resources for response and recovery efforts. It is important to recognize that pre-incident planning efforts could significantly reduce the time needed for incident recovery. Such planning could decrease the amount of time needed to return to normal transit service from perhaps a year or more (time needed for recovery without any pre-incident planning) to possibly a few months. For multiple reasons, it is unlikely that recovery from a CBR incident will be achievable in less than several weeks to a few months, and transportation owners/operators should plan for extended by-pass services, related operational adjustments, and communications with the public.

A generic biological restoration plan for major airports was developed as part of the Livermore research study. The plan includes templates for characterizing and removing the contamination and obtaining clearance to reopen the airport. It recommends actions for emergency responders, methods for sampling and analysis, and handling procedures for decontaminated waste. The restoration plan also evaluates the decontamination methods available, including liquid, gel, and gaseous reagents. Special emphasis is given to chlorine dioxide and vaporous hydrogen peroxide, the methods that were used to clean up anthrax-contaminated facilities in 2001. The plan pulls all of this work into a framework that decision makers can use in the event of bioterrorism.

To help authorities determine how clean a facility must be before it can be reopened, the National Research Council (NRC) of the National Academies prepared a framework for evaluating decontamination efforts that was issued in 2005 as *Reopening Public Facilities after a Biological Attack.* The published framework recommends risk assessment actions, public health safeguards, sampling procedures, and decontamination standards. No universal standard was offered for determining when a building would be safe to re-enter because the type of pathogen and the amount disseminated affect cleanup operations. Instead, the framework includes questions about pathogen characteristics—such as how far it has spread, whether it is transmissible between humans, and how long it will survive to pose a threat to help decision makers determine the appropriate response.

Many activities can greatly reduce the time required to re-establish airport operations if those activities are conducted before an actual biological weapon agent (BWA) release. Recommended pre-planning actions are summarized here by topic.

1. **Develop a concept of operations (CONOPS) for cleanup of a BWA release.** The CONOPS should be specific to the airport, should show the structure of the organizations involved in cleanup, and should identify their specific roles and responsibilities. Formation of a technical working group (TWG), an environmental clearance committee (ECC), and selection of members are strongly recommended before an incident occurs. Issues pertaining to local, state, and federal jurisdictions should be addressed, and stakeholders should be identified. The steps in the CONOPS will depend on whether an Incident of National Significance (INS) has been declared and may be dictated by the type of BWA used. The CONOPS should include two potential response scenarios for biological agents, one for a federal (INS) and one for a nonfederal (nonINS) response. The CONOPS should also identify the pros and cons of a federal versus nonfederal response. The CONOPS can be maintained in a Data Supplement. Identify alternative, backup locations for the emergency operations center (EOC).

2. **Ensure all facility information is readily accessible**. Locate all architectural drawings of terminals, boarding areas, and other areas. Locate all mechanical drawings of ventilation systems, drainage systems, and associated mechanical rooms. All potential entrance and exit points for gases, particles, or liquids should be identified (such as sumps, drain pipes, vent shafts, and so forth). The information could be summarized in a Data Supplement for quick access and initial planning. It is essential that legible and intelligible facility information be immediately accessible to remediation personnel. Consider placing the information on a geographical information system (with hardcopy backup) that would be controlled and maintained by airport personnel.

3. **Identify containment zones to prevent the spread of BWA and isolation zones to prevent the release of fumigant.** Assess the facility layout and identify potential sampling, characterization, fumigation, and decontamination zones. Identify logical containment and isolation zones and stipulate the means by which the zones are to be established. Isolation can be established at connector halls between major terminal areas. Fire doors can assist in isolation. Life-safety zones are used for smoke control and are often serviced by dedicated air-handling units (AHUs). Because they are defined by the AHUs of the airport HVAC system, they constitute logical zones for characterization and remediation. Decontamination zones are defined primarily by physical structures such as fire doors or corridors that can be easily sealed in the event of a release.

4. **Identify sampling and analytical resources.** Determine who will collect samples, such as initial screening samples and subsequent characterization and clearance samples. Meet with the local laboratory response network (LRN) laboratory and discuss sample throughput, reporting of results, and surge capacity. If needed, line up additional LRN analytical laboratories that can be tapped in the event that many samples are to be collected.

5. **Identify sampling zones and units.** Identify logical sampling zones and sampling units for the airport. Decide how the airport can be logically subdivided to facilitate environmental sampling. Sampling zones may be similar to the containment and isolation zones, or they

may be defined at a finer scale. It is possible that sampling zones and units may be different, depending on the agent released. However, it should be possible to construct sampling zones and units that could be reviewed and modified as necessary in the case of an actual event**.**

6. **Identify the most likely decontamination methods and experienced contractors to be used.** Evaluate the strengths and weaknesses of available decontamination methods. Select the most appropriate methods to use for different BWA attack scenarios. In some cases, it may be possible to use or upgrade in-house decontamination equipment. Identify staging areas or warehouses for equipment and supplies. Decide on the types and amounts of decontamination supplies needed and whether to purchase them in advance (some materials may have a short shelf life). Select potential contractors to employ as members of the decontamination team.
7. **Identify what to decontaminate in situ, remove for offsite treatment, or remove for disposal.** In most cases, easily removed and replaced items should not be retained, whereas structural components will be decontaminated in place. The decontamination reagent used will affect the decision of what items may be left in place. Whereas treatment in place should reduce the costs of the source-reduction step, critical equipment and items should be identified for removal and treatment offsite. If existing decontamination methods are not compatible with certain equipment, then identify alternative, backup, or replacement equipment.
8. **Determine initial disposition of contaminated materials and identify staging and storage areas for waste.** Decontaminating materials in place will reduce the potential for spreading contamination, but it may also damage certain equipment or materials. Disposition choices should be evaluated in advance of an event. Estimate waste-storage requirements on the basis of quantities of materials that might require disposal and on the decontamination technologies of choice. Initiate discussions with local waste-disposal facilities, including municipal waste landfills; construction and demolition debris landfills; hazardous waste landfills; and hazardous, municipal, and medical waste incinerators, if available. Discuss waste-disposal issues with the state solid-waste-management authority. Discuss wastewater management issues (e.g., wastewater from chlorine dioxide scrubbers) with local wastewater treatment facilities.
9. **Write a new, generic Health and Safety Plan (HASP).** Write a new HASP, or re-evaluate an existing one, on the basis of information provided in this Plan.
10. **Identify backup facilities to continue service**. In the event that one or more facilities is contaminated with a BWA, identify areas and other infrastructure that might be used for the resumption of travel in some capacity.
11. **Hold planning meetings at scheduled intervals**. Airport personnel should meet with prospective unified command (UC) and TWG members, responders, and stakeholders to continue to develop cleanup-related documents, policies, and guidance. Plans will change over time as technologies advance and local, state, and federal policies evolve.
12. **Conduct training exercises**. Airports should identify the scope of training activities appropriate for responding to BWA scenarios. Activities can range from simple, internal notification drills to full-scale, mass-decontamination exercises that take place over one or more days.

See Appendix A for checklists and other resources.

APPENDIX E: RECOVERY FUNDING SOURCES

(Note: Material in Appendix E was current as of October 2012. For the most current information, please see http://www.fhwa.dot.gov/programadmin/erelief.cfm and http://www.fema.gov/public-assistance-local-state-tribal-and-non-profit.)

This section provides a comparison of federal funding programs for transportation infrastructure and a detailed summary of all federal funding available for rebuilding and recovery.

Comparison of Federal Funding Programs

	FHWA – ER	FEMA – PA
Guiding Policies	Highway Trust Fund 23 USC 120, 125 23 CFR 635, 668 Emergency Relief Manual (August 2003 Interim Update)	Stafford Act, as amended 42 USC 645 44 CFR 204, 205, 206 Disaster Specific Guidance (DSG)
Categories of Damage Coverage	Emergency repair (i.e., debris removal) Permanent repair for damages resulting from a disaster (i.e., road base, roadway lighting)	Emergency work • Category A - Debris Removal • Category B - Protective Measures Permanent work • Category C - Roads and Bridges • Category D - Water Control Facilities • Category E- Buildings & Equipment • Category F - Utilities • Category G - Parks and Recreational Facilities Note: **FEMA does not reimburse for items eligible under FHWA ER**
Typical Federal Cost Share	Roads on federal lands - 100% Emergency repairs - up to 100% within the first 180 days Interstate highways- 90% Other highways - 80%	Category A: Maximum of 70 hours of time and material contract expenses - 75% Categories A & B: 72 contiguous hours within the Incident period, often 100% All Categories (A-G): 75% minimum, may increase based on Presidential declaration cost share
Funding Requests	State DOT district offices	State Division of Emergency Management
Eligible Project Cost Threshold	$5,000	Small Projects ≥ $1,000 Large Projects ≥ $57,500 (FY 2006)

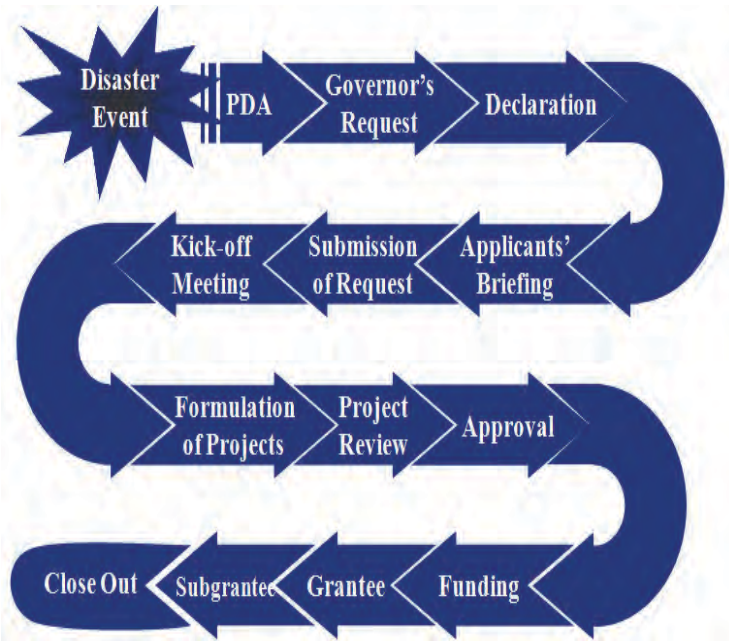
Debris Removal	Considered emergency repair Debris that is deposited by the event that it is needed to minimize damage, protect facilities, or restore essential traffic (reimbursed at 100%) Debris removal collection along federal-aid roadways (reimbursed at 100% for work completed within first 180 days)	Considered emergency work Debris removed to restore travel and protect health and safety on non-federal-aid eligible roadways. Considered Category B - Emergency Protective Measures (reimbursed at 100% within the 72-hour period) Considered Category A - Debris Removal to eliminate the threat to public health and safety along ALL roadways (private roads typically excluded). (Reimbursed at 75% for work completed within the first 180 days.)
Mitigation	Betterments - improve and prevent future damages, need supporting cost benefit analysis	Hazard mitigation - prevents future damages, need supporting cost benefit analysis. 406 Mitigation
Documentation	Uses Detailed Damage Inspection Reports (DDIRs) to document damages and costs.	Uses Project Worksheets (PWs) to document damages and costs.
	Both programs control the scope of work, control quantities, but do not control unit prices or current market prices of labor, equipment, and materials as long as they meet reasonable cost. Both programs require as much documentation as possible to be prepared and subsequently funded; this may include procurement documents, proposals, contracts, cost estimates, invoices, GPS coordinates, drawings, GIS maps, time sheets, expense forms, supply receipts, equipment logs, debris removal load ticket, landfill receipts, etc.	
Review Process	DDIRs are reviewed and approved by both state DOT and FHWA.	PWs are reviewed by FEMA and State Public Assistance personnel before being sent to the regional office for final review and funding. PWs greater than a million dollars will go to FEMA headquarters in Washington, DC, for review and funding.

Source: Adapted from FDOT Emergency Management

Federal Emergency Management Agency (FEMA) Public Assistance Grants

Public Assistance (PA) grants are FEMA's primary assistance program for state and local governments. These grants may be used to repair, replace, or restore disaster-damaged, publicly owned facilities and the facilities of certain private nonprofit organizations.

Disaster Funding Process and Key Deadlines



Key Deadlines

Application
Submit a Request for Public Assistance within 30 days of the designation of the declared disaster area.

Submit small projects within 60 days of the Kick-off meeting for 20% validation.

Appeals
Any determination related to federal assistance may be appealed. The appeal must be submitted to the grantee within 60 days of receipt of notice of the action which is being appealed.

Eligible Activities

This program has two types of eligible activities, emergency work and permanent work.

Emergency Work

Category	Description	Eligibility
A	Debris Removal	Debris removal is eligible when ▪ It eliminates an immediate threat to life, health, and safety ▪ It eliminates an immediate threat of significant damage to improved property ▪ It ensures economic recovery of the community and provides a benefit for the community-at-large Debris removal is generally the responsibility of the property owner. However, if debris is so widespread that public health, safety, or economic recovery of the community is threatened, the actual removal of debris from private property may be eligible.

B	Emergency Protective Measures	Emergency Protective Measures are actions taken by a community before, during, and following a disaster to save lives, protect public health and safety, or eliminate immediate threat of significant damage to improved public and private property through cost-effective measures.

Permanent Work

C	Roads and Bridge Systems	Eligible permanent work ▪ Must repair, restore, or replace disaster-damaged facilities in accordance with regulations ▪ Must restore to pre-disaster design, capacity, and function in accordance with applicable codes and standards ▪ Must be required as a result of the disaster ▪ May include cost-effective hazard mitigation measures
D - G	D. Water Control Facilities E. Public Buildings / Equipment F. Public Utilities G. Other (Parks, Recreation, etc.)	

Administrative Allowances

Stafford Act stipulates that each grant recipient be provided an allowance to meet the cost of administering the grant.	Administrative Allowances cover direct and indirect costs incurred in requesting, obtaining, and administering public assistance. No other administrative or indirect costs incurred by the applicant are eligible. Includes costs incurred for overtime pay, per diem, and travel expenses for state employees who participate in the administration of Public Assistance grants. It does not cover regular time labor costs and other costs directly associated with grant administration.
	In addition may be reimbursed for the necessary costs of requesting, obtaining, and administering federal assistance in accordance with 44 CFR § 13.22. A category Z, Project Worksheet (PW) is used to generate the reimbursement of the Grant Management Costs.

There is generally a 25% matching requirement, but the statute authorizes the President to waive part or the entire required match. Applicants performing restoration work on a damaged facility may make improvements to the facility while restoring the facility to its pre-disaster condition.

- The improvements must be approved by the grantor prior to construction.
- The applicant is responsible for the cost of the improvements. Federal funding is limited to the cost of restoration.

Public Assistance projects are processed as either small or large projects. If the project cost is less than the annually updated cost threshold amount ($63,900 for FY 2011), the project is processed as a small project. If the project cost equals or exceeds the threshold, the project is processed as a large project. Large projects are funded on a reimbursement basis as the project is completed.

Small Projects	Large Projects
Federal cost share is paid upon project approval. Funding is based on an initial cost estimate.	Federal cost share is paid as work is accomplished. Final assistance is based upon actual costs or an estimate using the Cost Estimating Format.

Forms and Documentation:

- A form called a project worksheet is utilized jointly by FEMA, Homeland Security and Emergency Management Division (HSEMD), and applicants to identify each project, scope of work, and cost estimate. Each project must be approved by FEMA before projects can move forward. The regulations specify that federal officials must obligate funds for approved applications within 45 days of the approval of applications for assistance.

To be eligible for reimbursement, costs must

- Be reasonable and necessary to accomplish eligible work.
- Comply with federal, state, and local laws and regulations.
- Include deductions of insurance proceeds, salvage value, and purchase discounts.

Time limits for project completion begin on the disaster declaration date:

- Emergency work must be completed within 6 months.
- Permanent work must be completed within 18 months.

FEMA may also extend the time limits when sufficient justification is submitted.

Alternate Projects: When restoration of a damaged facility or function does not serve the public welfare, an applicant may use a Public Assistance grant for another public facility.

- The alternate project must be approved by FEMA prior to construction.
- The alternate project may require an environmental assessment.

- Federal funding is limited to 75% of the federal share of the original project estimate or actual alternate project cost (whichever is less).

Specific eligibility requirements are spelled out in the FEMA Public Assistance Guide, available at http://www.fema.gov/government/grant/pa/index.shtm.

Supporting resources are available at http://www.fema.gov/government/grant/pa/resources.shtm.

Hazard Mitigation Grants

This program provides grants to states to implement mitigation measures during recovery from a disaster and to provide funding for previously identified mitigation measures to benefit the area. The purpose of the program is to reduce loss of life and property resulting from natural disasters and to enable mitigation measures to be implemented during the recovery from a disaster. Projects must be cost-effective. There is a matching requirement of 25%. As amended, the statute limits assistance to 75% of the cost of the hazard mitigation measure, with total assistance limited to 7.5% of the total assistance provided under the Stafford Act.

Eligible applicants include local jurisdictions, states, tribes, and certain private nonprofits that can apply through the state for the HMGP following a presidential disaster declaration.

Examples of projects under the HMGP include the following:

- Acquisition or relocation of structures located in a special flood hazard area
- Elevation of structures/utilities
- Structural and non-structural retrofitting of existing public buildings, facilities, or utilities to protect against wind, ice, or flood hazards
- Minor structural hazard control or protection projects such as storm water management (e.g., culverts, floodgates, retention basins)
- Localized flood control projects, such as floodwall systems, that are designed specifically to protect critical facilities and do not constitute a section of a larger flood control system
- Hazard Mitigation Planning

Pre-Disaster Mitigation Grants

This program provides grants and technical assistance to state, territorial, and local communities for cost-effective hazard mitigation activities that complement a comprehensive hazard mitigation program and reduce injuries, loss of life, and damage and destruction of property.

A minimum of $500,000 or 1.0% of appropriated funds is provided to each state and local government, with assistance capped at 15% of appropriated funds. Federal funds compose generally 75% of the cost of approved mitigation projects, except for small impoverished communities that may receive up to 90% of the cost.

Community Development Block Grant (CDBG) Funds

CDBG funds are not specifically meant for disaster recovery use. They are generally allocated to states for housing and community development purposes. In recent years, Congress has chosen to use this program as a vehicle for delivering additional disaster aid to states with major disasters. With each allocation, states must complete an "action plan" detailing plans for the funding. Once that occurs, the state can begin committing the funds to specific projects. This program is reimbursement only. Funds are never transferred to the state. Checks are cut for specific projects after their completion.

Under Section 108, a wide variety of large-scale projects are permissible that include construction, reconstruction, or installation of public facilities (including streets, sidewalks, and other site improvements).

CDBG funds can be used to repair or construct infrastructure—such as streets, water pipes, and sidewalks—that has a direct impact on the economic development of an area. For example, before a company can expand and create more jobs for residents in a designated service area, there may be infrastructure improvements that need to be made. CDBG funds can be used to make those improvements.

U.S. Department of Transportation (U.S. DOT) Funds

These funds are to assist DOTs with disaster-related transportation costs, including repairs and other expenses.

FHWA Emergency Relief Program

- Emergency Relief (ER) is a special program from the Highway Trust Fund, in which funds are available for the repair of federal-aid highways or roads on federal lands that have been seriously damaged by natural disasters or by catastrophic failures from an external cause. Applicability is based on the extent and intensity of the disaster. For example, damage to highways must be severe, occur over a wide area, and result in unusually high expenses to the highway agency. A catastrophic failure cannot be the result of an inherent flaw in the structure but must result from a sudden, disastrous impact such as a bridge collapsing after being struck by a barge.

This program supplements the commitment of resources by states, their political subdivisions, or other federal agencies to help pay for unusually heavy expenses resulting from extraordinary conditions.

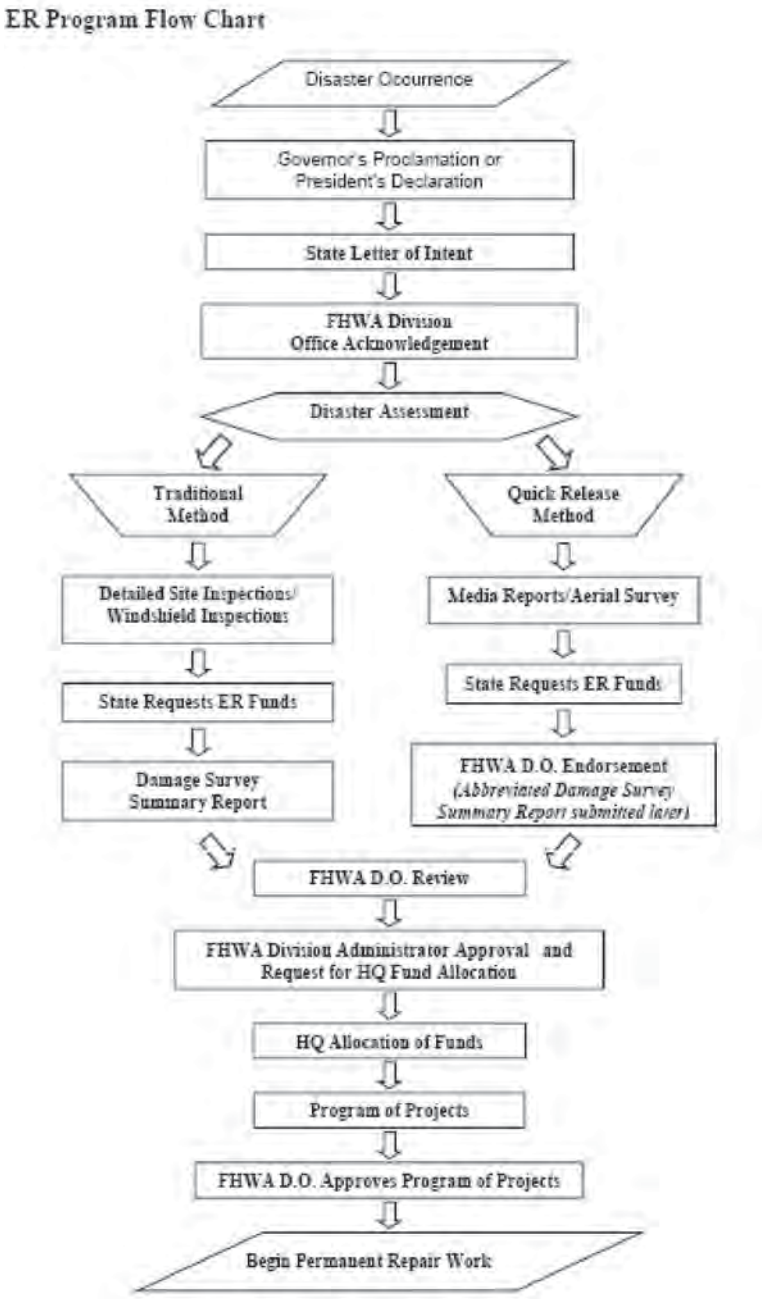
Funding and Eligibility	Funded through a $100 M permanent annual authorization Additional funding may be provided through supplemental appropriations	Disaster Threshold = $700,000 per state Site Threshold = $5,000 per site
Emergency Repairs	Restore essential traffic, minimize the extent of damage, or protect the remaining facilities Emergency repair work may include ▪ Debris removal to outside edge of shoulders ▪ Traffic control and temporary detours ▪ Stabilizing damaged roadways ▪ Immediate repairs to restore essential traffic	Eligible at 100% within 180 days Eligible at normal share beyond 180 days

The applicability of the ER program to a natural disaster is based on the extent and intensity of the disaster. Damage to highways must be severe, occur over a wide area, and result in unusually high expenses to the highway agency. Applicability of ER to a catastrophic failure due to an external cause is based on three criteria: (1) the failure was not the result of an inherent flaw in the facility but was sudden, (2) the failure caused a disastrous impact on transportation services, and (3) the failure resulted in unusually high expenses to the highway agency.

By law, the FHWA can provide up to $100 million in ER funding to a state for each natural disaster or catastrophic failure that is found eligible for funding under the ER program (commonly referred to as the $100 million per state cap). For a large disaster that exceeds the $100 million per state cap, Congress may pass special legislation lifting the cap for that disaster. As a general rule, the estimated cost for repairs from a disaster or catastrophic failure in a state must require at least $700,000 in ER funding before the FHWA will consider approving the disaster or catastrophic failure as eligible for funding under the ER program.

Approved ER funds are available at the pro-rata share that would normally apply to the federal-aid facility damaged. For Interstate highways, the federal share is 90%. For all other highways, the federal share is 80%. Emergency repair work to restore essential travel, minimize the extent of damage, or protect the remaining facilities that is accomplished in the first 180 days after the disaster occurred may be reimbursed at 100% federal share.

It is the responsibility of individual states to request ER funds for assistance in the cost of necessary repair of federal-aid highways damaged by natural disasters or catastrophic failures. A notice of intent to request ER funds filed by the state DOT with the FHWA Division Office located in the state will initiate the ER application process.



Source: FHWA Special Federal Aid Funding, Emergency Relief Manual.

For some states, the availability of state funding sources ends with the Disaster Emergency Fund. For others, however, additional resources may also be available for the recovery process, including additional funding from different state departments (e.g., the state DOT) for specific types of projects. For example, as directed by Minnesota Statutes Chapter 162.06 and 162.12, the Minnesota DOT (MnDOT) administers disaster assistance funds to state-aid roads and streets. In other cases, there may also be funding available from the affected counties or other localities, local private organizations, and nonprofit agencies. Additionally, in the aftermath of a

large disaster, some states opt to create a new funding program specifically targeted toward raising and allocating money for the recovery process.

In the event that a Governor's Declaration is made, but not a Presidential Declaration, disaster recovery funding comes first from the affected locality, as well as the area's respective county/parish. If these resources have been exhausted, then funding may also be provided via the aforementioned state Disaster Emergency Fund. Other state-level funding sources may be available from various state departments, as well as from federal agencies (for example, the FHWA ER funds do not require a Presidential Declaration), depending on the type of recovery projects being undertaken. Additional funding and resources may also be sought out from private organizations and nonprofit agencies.

Special Federal Legislation Funding Examples

Congress enacted special legislation because of the widespread devastation that resulted from Hurricane Katrina in the fall of 2005. P.L. 109-68, the Temporary Assistance for Needy Families (TANF) Emergency Response and Recovery Act of 2005, provided additional TANF funds and waived some program requirements for states affected by Hurricane Katrina.

P.L.109-87 authorized the Secretary of Transportation to make project grants for airports that incurred emergency capital costs because of Hurricanes Katrina or Rita.

Resources and Tools

See Appendix A for forms, worksheets, and other resources.

APPENDIX F: GLOSSARY OF TERMS AND DEFINITIONS

Arterial - A class of roads serving major traffic movements (high-speed, high volume) for travel between major points.

Arterial Highway - A major highway used primarily for through traffic.

Arterial Street - A class of street serving major traffic movements (high-speed, high volume) for travel between major points.

Bridge Management System (BMS) - A systematic process that provides, analyzes, and summarizes bridge information for use in selecting and implementing cost-effective bridge construction, rehabilitation, and maintenance programs.

Bus Lane – (1) A street or highway lane intended primarily for buses, either all day or during specified periods, but sometimes also used by carpools meeting requirements set out in traffic laws. (2) A lane reserved for bus use only. Sometimes also known as a "diamond lane."

Bus Priority System - A system of traffic controls in which buses are given a special advantage over other mixed-flow traffic (e.g., preemption of traffic signals or preferential lanes).

Change of Mode - The transfer from one type of transportation vehicle to another (i.e., automobile to bus or pedestrian to automobile).

Class I Railroad - Railroad with an annual operating revenue of at least $266.7 million.

Collector (Highway) - In rural areas, routes that serve intra-county rather than statewide travel. In urban areas, streets that provide direct access to neighborhoods and arterials.

Community – In the context of facilitating disaster recovery, community refers to a network of individuals and families, businesses, institutions, and other civic organizations that reside or operate within a shared geographical boundary and may be represented by a common political leadership at a regional, county, municipal, or neighborhood level.

Commuter Rail - Long-haul passenger service operating between metropolitan and suburban areas, whether within or across the geographical boundaries of a state, usually characterized by reduced fares for multiple rides and commutation tickets for regular, recurring riders.

Commuter Rail (Transit) - Urban passenger train service for short-distance travel between a central city and adjacent suburb. Does not include rapid rail transit or light rail service.

Congestion Management System (CMS) - Systematic process for managing congestion. Provides information on transportation system performance and finds alternative ways to alleviate congestion and enhance the mobility of people and goods to levels that meet state and local needs.

Corridor - A broad geographical band that follows a general directional flow connecting major sources of trips that may contain a number of streets, highways and transit route alignments.

Critical Infrastructure – Systems and assets, whether physical or virtual, so vital that their incapacity or destruction could have a debilitating impact on security, public health or safety, the economy, the environment, or any combination thereof, across any federal, state, regional, territorial, or local jurisdiction.

Expressway - A controlled access, divided arterial highway for through traffic with intersections that are usually separated from other roadways by differing grades.

Federal-Aid Highways - Those highways eligible for assistance under Title 23 U.S.C., except those functionally classified as local or rural minor collectors.

Ferry Boat - A boat providing fixed-route service across a body of water.

Ferryboat (Transit) - Vessels that carry passengers and/or vehicles over a body of water. Generally steam or diesel powered, ferryboats may also be hovercraft, hydrofoil, and other high-speed vessels. The vessel is limited in its use to the carriage of deck passengers, or vehicles, or both. A ferryboat operates on a short run on a frequent schedule between two points over the most direct water routes (other than in ocean or coastwise service) and is offered as a public service of a type normally attributed to a bridge or tunnel.

Freeway - A divided arterial highway designed for the unimpeded flow of large traffic volumes. Access to a freeway is rigorously controlled, and intersection grade separations are required.

General Aviation – (1) All civil aviation operations other than scheduled air services and nonscheduled air transport operations for taxis, commuter air carriers, and air travel clubs that do not hold Certificates of Public Convenience and Necessity. (2) All civil aviation activity except that of air carriers certificated in accordance with Federal Aviation Regulations, Parts 121, 123, 127, and 135. The types of aircraft used in general aviation range from corporate, multiengine jet aircraft piloted by professional crews to amateur-built, single-engine, piston-driven, acrobatic planes to balloons and dirigibles.

Heavy Rail (Transit) - An electric railway with the capacity to transport a large volume of passenger traffic and characterized by exclusive rights-of-way, multicar trains, high speed, rapid acceleration, sophisticated signaling, and high-platform loading. Also known as subway, elevated (railway), or metropolitan railway (metro).

High-Occupancy Vehicle (HOV) - Vehicles carrying two or more people. The number that constitutes an HOV for the purposes of HOV highway lanes may be designated differently by different transportation agencies.

High-Occupancy Vehicle Lane - Exclusive road or traffic lane limited to buses, vanpools, carpools, and emergency vehicles.

Highway - Any road, street, parkway, or freeway/expressway that includes rights-of-way, bridges, railroad-highway crossings, tunnels, drainage structures, signs, guardrail, and protective structures. The highway further includes that portion of any Interstate or international bridge or tunnel and the approaches thereto (23 U.S.C. 101a).

Infrastructure – (1) In transit systems, all the fixed components of the transit system, such as rights-of-way, tracks, signal equipment, stations, park-and-ride lots, bus stops, and maintenance facilities. (2) In transportation planning, all the relevant elements of the environment in which a transportation system operates. (3) A term connoting the physical underpinnings of society at large, including, but not limited

to, roads, bridges, transit, waste systems, public housing, sidewalks, utility installations, parks, public buildings, and communications networks.

Intelligent Transportation Systems (ITS) - The application of advanced technologies to improve the efficiency and safety of transportation systems.

Intermediate Recovery – Involves returning critical infrastructure and essential government or commercial services back to a functional, if not pre-disaster state. Such activities are often characterized by temporary actions that provide a bridge to permanent measures.

Intermodal - The ability to connect, and the connections between, modes of transportation.

Intersection – (1) A point defined by any combination of courses, radials, or bearings of two or more navigational aids. (2) Used to describe the point where two runways, a runway, and a taxiway, or two taxiways cross or meet.

Interstate Highway – Limited-access, divided highway of at least four lanes designated by the FHWA as part of the Interstate System.

Interstate Highway (Freeway or Expressway) - A divided arterial highway for through traffic with full or partial control of access and grade separations at major intersections.

Lane - A portion of a street or highway, usually indicated by pavement markings, that is intended for one line of vehicles.

Large Regionals (Air) – Air carrier groups with annual operating revenues between $20 million and $99,999,999.

Level of Service (LOS) - A qualitative assessment of a road's operating conditions. For local government comprehensive planning purposes, level of service means an indicator of the extent or degree of service provided by, or proposed to be provided by, a facility based on and related to the operational characteristics of the facility. Level of service indicates the capacity per unit of demand for each public facility.

Light Rail - A streetcar-type vehicle operated on city streets with semi-exclusive rights-of-way or exclusive rights-of-way. Service may be provided by step-entry vehicles or by level boarding.

Local Street - A street intended solely for access to adjacent properties.

Long-term Recovery – Process of recovery that follows a disaster event and may continue for months and years. Examples include the complete redevelopment and revitalization of the damaged area, which could mean returning the area to conditions set in a long-term recovery plan.

Maritime - Business pertaining to commerce or navigation transacted upon the sea or in seaports in such matters as the court of admiralty has jurisdiction.

Memorandum of Understanding (MOU) - A document providing a general description of the responsibilities that are to be assumed by two or more parties in their pursuit of some goal(s). More specific information may be provided in an associated Statement of Work (SOW).

Metropolitan Planning Organization (MPO) – (1) Regional policy body, required in urbanized areas with populations over 50,000, and designated by local officials and the governor of the state. The MPO is responsible, in cooperation with the state and other transportation providers, for carrying out the metropolitan transportation planning requirements of federal highway and transit legislation. (2) Formed in cooperation with the state, develops transportation plans and programs for the metropolitan area. For each urbanized area, an MPO must be designated by agreement between the Governor and local units of government representing 75% of the affected population (in the metropolitan area), including the central cities or cities as defined by the Bureau of the Census, or in accordance with procedures established by applicable state or local law (23 U.S.C. 134(b)(1)/Federal Transit Act of 1991 Sec. 8(b)(1)).

Minor Arterials (Highway) - Roads linking cities and larger towns in rural areas. In urban areas, roads that link but do not penetrate neighborhoods within a community.

Mitigation – Activities providing a critical foundation in the effort to reduce the loss of life and property from natural and/or manmade disasters by avoiding or lessening the impact of a disaster and providing value to the public by creating safer communities. Mitigation seeks to fix the cycle of disaster damage, reconstruction, and repeated damage. These activities or actions, in most cases, will have a long-term sustained effect.

Mode - A specific form of transportation, such as automobile, subway, bus, rail, or air.

Multimodal - The availability of transportation options using different modes within a system or corridor.

National Highway System (NHS) - The system of highways designated and approved in accordance with the provisions of 23 U.S.C. 103b.

Occupancy - The number of persons, including driver and passenger(s) in a vehicle. Nationwide Personal Transportation Survey (NPTS) occupancy rates are generally calculated as person miles divided by vehicle miles.

Paratransit – (1) Comparable transportation service required by the Americans with Disabilities Act (ADA) for individuals with disabilities who are unable to use fixed-route transportation systems. (2) A variety of smaller, often flexibly scheduled-and-routed transportation services using low-capacity vehicles, such as vans, to operate within normal urban transit corridors or rural areas. These services usually serve the needs of persons that standard mass-transit services would serve with difficulty or not at all. Often, the patrons include the elderly and persons with disabilities.

Peak Period - A portion of the day in which the heaviest demand occurs for a given transportation corridor or region, usually defined as a morning or evening period of 2 or more hours.

Port - Harbor with piers or docks.

Private Carrier - A carrier that provides transportation service to the firm that owns or leases the vehicles and does not charge a fee.

Privately Owned Vehicle (POV) – (1) A privately-owned vehicle or privately-operated vehicle. (2) Employee's own vehicle used on official business for which the employee is reimbursed.

Public Transit System - An organization that provides transportation services owned, operated, or subsidized by any municipality, county, regional authority, state, or other governmental agency, including

those operated or managed by a private management firm under contract to the government agency owner.

Rail - A rolled steel shape laid in two parallel lines to form a track for carrying vehicles with flanged steel wheels.

Ramp Metering - A system used to reduce congestion on a freeway facility by managing vehicle flow from local-access on-ramps. An on-ramp is equipped with a traffic signal that allows vehicles to enter the freeway.

Recovery – The development, coordination, and execution of service- and site-restoration plans; the reconstitution of government operations and services; individual, private-sector, nongovernmental, and public-assistance programs that provide housing and to promote restoration; long-term care and treatment of affected persons; additional measures for social, environmental, and economic restoration; evaluation of the incident to identify lessons; post incident reporting; and development of initiatives to mitigate the effects of future incidents.

Regional Planning Organization (RPO) - An organization that performs planning for multi-jurisdictional areas. MPOs, regional councils, economic development associations, and rural transportation associations are examples of RPOs.

Resilience – "The ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events" (Committee on Increasing National Resilience to Hazards, Disasters and Committee on Science, Engineering, and Public Policy, The National Academies; *Disaster Resilience: A National Imperative*; The National Academies Press, 2012, p. 1).

Response – Immediate actions to save lives, protect property and the environment, and meet basic human needs. Response also includes the execution of emergency plans and actions to support short-term recovery.

Restoration – Returning a physical structure, essential government or commercial services, or a societal condition back to its pre-disaster state through repairs, rebuilding, or reestablishment.

Road - An open way for the passage of vehicles, persons, or animals on land.

Road Class - The category of roads based on design, weatherability, governmental designation, and U.S. DOT's functional classification system.

Short-term Recovery – Phase of recovery in which the scope of damages and needs are assessed, basic infrastructure is restored, and recovery organizations and resources are mobilized.

Stabilization – The process by which the immediate impacts of an event on community systems are managed and contained.

Stakeholders - Individuals and organizations involved in or affected by the transportation planning process. Includes federal/state/local officials, MPOs, transit operators, freight companies, shippers, and the general public.

Sustainability – Meeting the needs of the present without compromising the ability of future generations to meet their own needs

Underserved Populations/Communities – Groups that have limited access or barriers to access to resources or are otherwise disenfranchised. These groups include those who are socioeconomically disadvantaged, persons who have limited English proficiency, people who are geographically isolated or educationally disenfranchised, minority groups, women and children, individuals with disabilities and others with access and functional needs, and older people.

Urban Highway - Any road or street within the boundaries of an urban area. An urban area is an area including and adjacent to a municipality or urban place with a population of 5,000 or more. The boundaries of urban areas are fixed by state highway departments, subject to the approval of the FHWA, for purposes of the federal-aid highway program.

Vanpool (Transit) - Public-sponsored commuter service operating under prearranged schedules for previously formed groups of riders in 8- to 18-seat vehicles. Drivers are also commuters who receive little or no compensation.

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation