Bay Area Regional Disaster Resilience Initiative

Infrastructure Interdependencies Workshop I – Utilities and Transportation Systems

Summary Report of Proceedings

Held January 31, 2012

at the Association of Bay Area Governments, Oakland, CA

Executive Summary

In response to the growing awareness that a better understanding of how infrastructure systems will impact post-disaster recovery is needed, more than 150 representatives of government, private sector, and non-profit organizations met at the Association of Bay Area Governments in Oakland, CA, on January 31, 2012 for the Infrastructure Interdependencies Workshop I. The Workshop focused on disaster recovery needs, gaps, and potential improvement activities associated with the interconnected energy, communications, and transportation infrastructures that serve the Bay Area.

The Workshop was the second event in a 14-month Initiative undertaken by the Association of Bay Area Governments (ABAG) and the Bay Area Economic Council with a broad coalition of Bay Area stakeholder organizations and associations to develop a Regional Disaster Resilience Action Plan focusing on disaster recovery. Co-Organizers of the Workshop included: the Association of Bay Area Governments, Bay Area Center for Regional Disaster Resilience, Bay Area Council, California Resiliency Alliance, East Bay Municipal Utility District, Alameda County Water District, San Jose Water Company, and Nexis Preparedness Systems (also the Workshop sponsor).

The objectives of the workshop were to better understand how a major earthquake could impact the region's utilities and transportation systems; increase understanding of regional infrastructure interdependencies that could impact recovery from a disaster; highlight the challenges for businesses that depend on these infrastructures; foster stakeholder collaboration to address these challenges; and develop the mutually beneficial relationships needed for building a disaster resilient Bay Area.

The workshop consisted of four sessions of presentations focusing on electric power and natural gas, water systems, transportation systems (road, public transportation, and maritime transportation), and communications and critical IT systems infrastructure. Other activities included interactive participant discussions and facilitated breakout group discussions.

Key Outcomes

The most significant lessons learned from the Workshop fell into the following five areas: understanding infrastructure interdependencies; stakeholder collaboration; recovery roles, responsibilities and decision-making; regional situational awareness during recovery; and moving beyond response to awareness of recovery needs. The top issues are summarized below.

1. **Current understanding of infrastructure interdependencies is very limited.** Significantly more in-depth analysis of infrastructure interdependencies is needed to understand the extent of damage to equipment, systems and structures, and to determine realistic timelines for restoration after a disaster. This level of analysis and understanding will require better risk assessment processes and tools, particularly with a regional focus, to address interdependencies and how they cause system vulnerabilities; economic, environmental, and societal consequences; and enable identification of cost-effective mitigation measures.

2. **Collaboration among infrastructure sectors, other essential service providers, and the broader stakeholders on disaster preparedness and recovery efforts is limited, but growing.** Service providers and stakeholders should explore strengthening and expanding existing coordination mechanisms or creating new ones. Coordination and communication should occur before a disaster, to better understand interdependencies, vulnerabilities, and assumptions, as well as during the immediate response and recovery phases to expedite restoration. A Bay Area Regional Emergency Operations Center should be created that can facilitate this collaboration for disaster response and recovery. This new local regional EOC would seamlessly interface with the CalEMA-led Coastal Regional EOC (REOC), which has recently relocated from Oakland to Sacramento for budget reasons.

3. **No regional disaster recovery framework or process currently exists for operational and financial decision-making post-disaster.** Such a framework could expedite restoration of utilities, communications, transportation, and other critical infrastructure and essential services. This step would be vital to developing a workable decision-making system with identified participating organizations before it is needed.

4. **Regional situational awareness during recovery is essential for decision-making.** It is necessary to provide essential information for utilities, government, and private sector organizations to make individual and collective decisions about outages, damaged infrastructure, transportation disruptions, and related debris and transportation hazards issues. There are already activities underway in the Bay Area that support this information-sharing, and existing technologies that can be leveraged for this purpose. Efforts should be made to begin focused development of, and integration with existing capabilities, a system to provide this necessary common operating picture.

5. **Many stakeholders with years of experience focusing on disaster response find it challenging to look beyond the immediate post-disaster period.** Planning for recovery and long-term restoration actions that will take months, and in some cases years, is a relatively new way of thinking in disaster planning and requires new skill sets and additional stakeholders to be at the table. Regional recovery and resilience-focused exercises are useful tools to raise stakeholder awareness, foster cross-sector, multi-jurisdiction collaboration, and identify actions to build Bay Area disaster resilience.

The workshop closed with a short discussion of follow-on activities for the Bay Area Disaster Resilience Initiative, including the second Infrastructure Interdependencies Workshop that will focus on remaining critical infrastructures and service providers, and a scenario-based discussion forum to further examine regional interdependencies and other recovery-associated needs and capabilities for inclusion in the Action Plan.

All materials from the workshop, including presentations and this summary, are available on the ABAG website at **http://quake.abag.ca.gov/resilience/workshops**.

Table of Contents

EXECUTIVE SUMMARY I

TABLE OF CONTENTS III

INFRASTRUCTURE INTERDEPENDENCIES WORKSHOP I – UTILITIES AND TRANSPORTATION SYSTEMS 1

OVERVIEW 1

1. WORKSHOP GOAL AND OBJECTIVES 2

2. SCOPE AND FORMAT 2

3. HIGHLIGHTS OF PROCEEDINGS AND PARTICIPANT DISCUSSIONS 3

3.1. Opening Remarks 3

3.2 Regional Interdependencies and Associated Earthquake Impacts Overview 4

3.3. Session 1: Energy – Electric Power and Natural Gas 5

3.4. Session 2: Water Systems 7

3.5. Breakout Group Discussions 9

3.6. Working Lunch Presentation 11

3.7. Session 3: Transportation – Road, Rail, and Maritime 12

3.8. Session 4: Communications and Critical Information Technology Systems 14

4. WORKSHOP ADDITIONAL OUTCOMES 16

5. NEXT STEPS 17

APPENDIX A WORKSHOP PARTICIPATING ORGANIZATIONS 18

APPENDIX B PLANNING TEAM MEMBERS 20

APPENDIX C BREAKOUT SESSION QUESTIONS/ INTERDEPENDENCIES IDENTIFICATION MATRICES 21

APPENDIX D INFRASTRUCTURE INTERDEPENDENCIES BACKGROUNDER 24

Infrastructure Interdependencies Workshop I – Utilities and Transportation Systems

Overview

In response to the growing awareness that a better understanding of how infrastructure systems will impact post-disaster recovery is needed, more than 150 representatives of government, private sector, and non-profit organizations met at the Association of Bay Area Governments in Oakland, CA, on January 31, 2012 for the Infrastructure Interdependencies Workshop I. The Workshop focused on disaster recovery needs, planning gaps, and potential improvement activities associated with the interconnected energy, communications, and transportation infrastructure systems that serve the Bay Area.

The Infrastructure Interdependencies Workshop I was the second regional event in a 14-month Initiative undertaken by the Association of Bay Area Governments (ABAG) and the Bay Area Economic Council in collaboration with a broad coalition of Bay Area stakeholder organizations and associations to develop a Regional Disaster Resilience Action Plan focusing on disaster recovery. Infrastructure interdependencies are a significant focus of the Initaitive, because these linkages will determine how quickly and effectively essential Bay Area services, businesses, local governments, schools, community institutions, and other organizations will resume operations, and housing and commercial buildings repaired and rebuilt.[1]

The focus of this Workshop was on deepening understanding of how infrastructure system interdependencies will impact the post-disaster recovery and what actions will be needed to quickly restore utilities and transportation systems that serve the Bay Area. These utilities include energy systems (electric power, natural gas, and petroleum fuels), water and wastewater systems, and communications and critical IT systems. Transportation infrastructure includes road, rail, and maritime systems, including bridges and tunnels.

Elsewhere in the Bay Area, work is already underway by the San Francisco Lifelines Council and some jurisdictions and infrastructure operators in the Bay Area to examine impacts from earthquakes and other events, and gain a better understanding of the interconnections among infrastructure systems and actions that may lessen the cascading consequences of damage or disruption. However, this work largely focuses on specific systems or municipalities, and to date there has not been a focus on interdependent infrastructures serving the 12-county Bay Area region or how prolonged disruptions could complicate region-wide recovery activities.[2]

Workshop I Co-Organizers and Planning Team

---

[1] An overview of the Bay Area Regional Disaster Resilience Initiative, the Initial Draft Action Plan Framework, and Initiative Kick-Off Workshop Summary of Proceedings Report can be obtained on the ABAG website: http://quake.abag.ca.gov/resilience/.

[2] The second Interdependencies Workshop, to be held in early May, will focus on other infrastructures and services—banking and financial institutions, community and academic institutions, hospitals and healthcare, sea and airports, commercial enterprises and government services, etc.

Co-Organizers of the Infrastructure Interdependencies Workshop I included the Association of Bay Area Governments, Bay Area Center for Regional Disaster Resilience, Bay Area Council, California Resiliency Alliance, East Bay Municipal Utility District, Alameda County Water District, San Jose Water Company, and Nexis Preparedness Systems, who also served as the Workshop sponsor. These organizations and several others contributed time and effort to developing the workshop.[3] *(See Appendix B for full list of Workshop Planning Team members.)*

1. Workshop Goal and Objectives

The overall goal of the workshop was to increase understanding of how infrastructure dependencies and interdependencies can exacerbate the consequences of a major earthquake or other disaster and impede recovery and restoration; enable stakeholder information sharing that can highlight interdependencies-related issues and preparedness gaps; and identify potential actions to incorporate into the Bay Area Regional Disaster Resilience Action Plan and other organizational continuity and recovery plans.

Specific objectives included:

1. Raise awareness of how earthquake scenarios could impact the region's interdependent energy, water/wastewater, communications, and transportation systems.

2. Better understand how infrastructure interdependencies may impact recovery actions, such as:
   - Assessing damage and restoring services;
   - Developing recovery plans and processes for determining restoration;
   - Communicating to key customers and the public expected restoration timelines;
   - Dealing with policies, regulations and other constraints that could impede restoration.

3. Highlight the challenges for businesses that depend on these utilities and transportation systems, and requirements for business resumption and economic recovery.

4. Underscore the value of public, private sector, cross-function and multidiscipline stakeholder cooperation and collaboration in meeting the above interdependencies challenges.

5. Provide opportunities to develop mutually beneficial relationships during the workshop.

2. Scope and Format

The day-long Workshop was limited to utilities and transportation providers to present an opportunity for participants to have more in-depth information from infrastructure representatives and discussion of interdependencies-related issues and challenges. The major

---

[3] Funding for the Initiative is provided by the Regional Catastrophic Preparedness Grant Program (RCPGP) of the Bay Area Urban Areas Security Initiative (UASI) with support by private sector and other contributions.

activities consisted of four sessions of presentations by infrastructure providers focusing on electric power and natural gas, water systems, transportation (roads, public transportation, and maritime transportation), and communications and critical IT systems infrastructure. The day also included interactive participant discussions, facilitated breakout group discussions,[4] and a presentation on infrastructure disaster preparedness needs during the working lunch by the workshop sponsor. Participants were provided at the beginning of the workshop with discussion questions for the breakout session and two matrices to fill out during the workshop - one to enable them to rank the importance of specific interdependencies for utilities, transportation services, and their own organizations, and a second to rank the severity of consequences to interdependent utilities and transportation from disruptions of these services. These matrices were provided to increase organizational awareness and were not collected *(See Appendix C for issues questions and matrices).*

3. Highlights of Proceedings and Participant Discussions

Note: As in the case of the Nov. 1, 2011 Initiative Kick-Off Workshop, information gathered from the presentations and participant observations and discussions will be augmented with lessons learned from other regional workshops, exercises, and activities, and data collected on Bay Area plans, tools, technologies and other capabilities and incorporated into the Action Plan and supporting Gap Analysis.

The following narrative represents the highlights and key points from each of the activities on the day's agenda.

3.1. Opening Remarks

Nancy Ward, Regional Administrator, FEMA Region IX, set the tone for the Workshop by emphasizing the need to go beyond planning for response to address disaster recovery and to engage the "whole community" of stakeholders—public, private sector, and non-profits—to develop communities that are resilient to all types of disasters. She noted that government could not shoulder the burden for recovery given that 85-90 percent of infrastructure was operated by the private sector, and federal funds would continue to shrink.

She said that FEMA Region IX has been working on catastrophic disaster planning with the state and localities, and that interdependencies were a concern, particularly in the areas of water and transportation systems disruptions. She added that restoration of lifelines was the key to recovery, but that "we rely on what we think we know."

She asked participants to consider that a major earthquake affecting the Bay Area could impact 1000 bridges, disrupt BART operations for two years, and "make Hurricane Katrina look like a garden variety flood." She concluded by commending the Workshop organizers for holding an

---

[4] Breakout facilitators were volunteer members of the Workshop Development Team:
Stephen Baruch, Emergency Management & Business Continuity Advisor, Nexis Preparedness Systems
Peter Ohtaki, Executive Director, California Resiliency Alliance, and
Paula Scalingi, Executive Director, Bay Area Center for Regional Disaster Resilience

event that can better spotlight Bay Area capacities, capabilities, and recommended actions that can improve Bay Area disaster resilience.

3.2 Regional Interdependencies and Associated Earthquake Impacts Overview

Paula Scalingi, Executive Director, Bay Area Center for Regional Disaster Resilience, provided a short overview of infrastructure interdependencies and their importance for regional and community resilience. She drew participants' attention to the *Infrastructure Interdependencies Backgrounder* document provided in the Workshop handout materials (*See Appendix D*) that described how interdependencies are a major determinant of vulnerabilities, consequences and risk and have significant implications for recovery and long-term restoration. She pointed out that these interdependencies are highly complex and difficult to address because they are outside organizational control, and may extend beyond a region, crossing state, national, and international borders. She commented that increasing our understanding of interdependencies required identifying the threats of greatest concern, assets and services that, if destroyed, damaged, or disrupted, could adversely affect other systems or services, how interdependencies change with the length of a disruption, and how backup systems or other mitigation measures could reduce interdependency problems and improve resilience. This necessitates a comprehensive, collaborative approach, such as that taken by the Bay Area Regional Resilience Initiative, which enables "whole community" stakeholders through workshops, exercises, and other activities to share information to illuminate and lessen impacts from interdependencies–associated vulnerabilities.

Area Disaster Resilience Initiative Update

She closed with a status report on Bay Area Disaster Resilience Initiative activities. She explained that since the Initiative began in August 2011 by convening a Bay Area Resilience Coalition of stakeholder organizations, two workshops had been conducted to explore resilience challenges. The stakeholders had identified focus areas and priority issues they wanted included in the Action Plan and these had been incorporated into the Action Plan Framework. She noted that production of the Gap Analysis of current disaster recovery capabilities and needs was underway. She outlined the remaining activities, included planning and conducting an Interdependencies Workshop II focusing on remaining infrastructures/service providers, a scenario-based event to examine significant issues for the Action Plan, development and production of the Action Plan, and an implementation strategy to determine project requirements, milestones, funding and other assistance.

Danielle Hutchings, Earthquake and Hazards Program Coordinator, ABAG, provided an overview of impacts an earthquake may have on utilities, transportation, and communications/critical IT systems. She pointed out that there were seven earthquake faults in the region that could cause earthquakes of 6.7 magnitude or larger.

Water and Wastewater

Addressing water and wastewater vulnerabilities, she pointed out that there are more than 100 water retailers on the western side of the Bay Area and that in the event of a major Hayward fault earthquake, there could be from 6,000 to 10,000 water pipeline breaks or major leaks, compared

to 507 in the1989 Loma Prieta earthquake. The Hetch-Hetchy aqueducts, EBMUD aqueducts, South Bay aqueduct, and numerous local pipelines also cross the Hayward fault and are vulnerable to damage, yet improvements have been made to many of these systems at fault crossings.

The Delta is also a major concern for the regional water system. Seventy-five percent of the region's water is supplied by water systems that receive all or part of their supply from the Delta or have aqueducts passing through the Delta. A Hayward fault earthquake could cause Delta levee failures and could disrupt the transport of fresh water for several years. She observed that some water districts lack access to alternative sources of water if their main supply were disrupted.

Transportation

She described the regional transportation system, which consists of a network of eight toll bridges, 2,000 state-owned and 2,000 locally owned overpasses, interchanges, and smaller bridges, 20,800 miles of highways and roads, 9,000 miles of bus routes, 750 miles of bikeways, and 5 commuter ferry lines. She noted that in a major earthquake there could be as many as 1,700 road closures and damage to the Berkeley Hills BART tunnel that would likely take more than two years to restore to full service. Large portions of roads, bridge approaches, railways, airport runways, and the region's ports would also be subject to damage due to liquefaction.

Energy

Regarding energy, she stated that most of the electric power routed to the East Bay travels through two transmission stations in Moraga and El Sobrante that could be damaged. The gas and electric distribution systems are also vulnerable to system disruptions due to building damage, shaking and liquefaction. A high proportion of customers could either lose or shut off their gas service for fear of fires due to gas line leaks, requiring inspection and relighting of pilot lights across the Bay Area by infrastructure provider employees.

Communications and IT

Communications and critical IT systems could also be subject to significant damage and disruption. She observed that network servers are not considered essential facilities and may be housed in vulnerable buildings. Loss of power for a prolonged period could increase the length of service disruption, although communications providers can provide temporary cell towers that can be deployed quickly.

3.3. Session 1: Energy – Electric Power and Natural Gas

Jonathan Frisch, Manager Business Continuity & Emergency Planning, Corporate Security, Pacific Gas and Electric Company, provided an overview of PG&E Bay Area electric and gas systems, potential impacts from a major earthquake, and PG&E recovery priorities.

Overview of System

Opening with a quote from Marshall McLuhan that "the electric age … established a global network that has much the character of our central nervous system," he described the PG&E system as huge, encompassing wind and solar power, dams, natural gas pipelines, gas storage facilities, and an electric transmission and distribution network connected with the western U.S. power grid. PG&E does not generate significant power in the Bay Area but brings it in from outside the region. The PG&E service area has 141,215 circuit miles of electric distribution lines, 18,616 circuit miles of interconnected transmission lines, 42,141 miles of natural gas distribution pipelines, 6,438 miles of transportation pipelines, 5.1 million electric customer accounts, 4.3 million natural gas customer accounts, and 20,000 employees.

Expected Damage and Key Interdependencies

Damage to the region's energy systems in a major earthquake would depend on a variety of factors including the fault, the epicenter, magnitude, time of day, day of week, season, extent of liquefaction, landslides, subsidence, structural damage including building collapses, fires, and adjacent infrastructure damage (water, sewer, roadways). He noted that PG&E assets, including gas pipelines, traverse earthquake fault lines and areas where liquefaction is an issue, or may be co-located with water pipelines and other structures that could cause simultaneous infrastructure failures if the other systems were damaged. Recovery needs in turn would depend on transportation disruptions and related logistics issues; availability of personnel, equipment, replacement parts, and fuel for repair vehicles; the ability of repair crews to get into damaged areas, availability of communications, and safety considerations; frequency and size of aftershocks; and operational and system restoration requirements. For example, PG&E has warehouses with equipment needed for repairs but these may be damaged or inaccessible. Operators' need to balance the electric load could create electricity reliability problems during recovery. He pointed out that transmission would need to be restored before distribution to customers for both electric and gas systems. Gas service restoration could take much longer, especially if many residents turn off their own gas, because there is a limit on how many homes and businesses can be restored in 24 hours. Damaged underground pipelines, cables, and other assets would take longer to repair than those above ground.

Existing Efforts to Speed Recovery

Post-disaster restoration priorities would also "depend" on a variety of factors. PG&E has a pre-defined priority list of critical need customers (e.g., hospitals, water systems that require power for pumping) but restoration priority is primarily an operational decision. PG&E's approach to recovery will be regional and system-wide and will address local government and community needs through local Emergency Operations Centers or the State EOC. Having current information on recovery needs and actions of other infrastructures and government decision-making on recovery priorities and issues will be essential.

Interactive Discussion

Participant questions and comments centered on the following issues:

- **Lessons learned for energy systems restoration from the Loma Prieta earthquake and other emergencies.** Discussion centered on the need for close communication and coordination between PG&E and localities on priorities and on areas where restoration or mitigation measures are challenging (e.g., the Santa Cruz Mountains) based on experiences from previous disasters, including Loma Prieta. However Frisch noted that Loma Prieta was "far from a worst case scenario," so lessons learned may not necessarily apply to a greater disaster.

- **How to obtain reliable information on road closures for utilities to expedite disaster recovery.** PG&E will rely on Caltrans, local news reports, and reports from its crews to gain a clear picture of road, bridge, and overpass damages and closures. This information is essential in planning where to send crews for repairs. Discussion followed on how to gain broad situational awareness of debris and other transportation impediments through development of a social media transportation hazard alert capability.

- **How Smart Grid technologies can support or impede resilience.** Frisch pointed out that if Smart Grid systems are operational in a disaster, they can provide PG&E much better information to aid service restoration. However, if these systems are out, then this can exacerbate restoration challenges. It was important to recognize that there are evolving energy-related IT technological advances, and it is necessary to address security and resilience challenges.

- **How PG&E is addressing disaster mitigation needs and a potential forum for mitigation investment decisions.** Frisch said that communities can influence mitigation priorities and that there is an "opportunity for dialogue" and collaboration; the California Public Utilities Commission is the mechanism where investment decisions would be made.

3.4. Session 2: Water Systems

Jim Wollbrinck, Security and Emergency Preparedness Specialist, San Jose Water Company

Overview of System

San Jose Water is the largest water utility in Santa Clara County, with a 138 square mile service area, 230,000 customers, and 2,500 miles of water main. There are 128 water utilities in the County, including eight major and 99 large water retailers, and three waste water utilities.

Key Interdependencies and Gaps

Challenges in a major disaster will be competition for resources among the region's 1,033 potable water utilities, 554 of them major systems, and interdependencies-related issues—supply chain disruptions affecting just-in-time deliveries of chemicals for water treatment, repair materials, and particularly fuel for back-up power generation and maintenance vehicles. Fuel distribution companies will shut down during a disaster. Other significant areas where improvement is needed is better coordination among the Bay Area's critical infrastructures and key resources, particularly with important service providers, e.g., PG&E, AT&T, Sprint, and fuel companies. A key gap is the lack of integration of waste water systems with water systems in

emergency planning and exercises. Regulatory issues pose additional problems. There are constraints on fuel stockpiles and air quality standards limit testing of power generators, and public health "do not use" or "boil before use" requirements that can affect restaurants, hospitals, and families.

Existing Efforts to Speed Recovery

There is good cooperation among the eight major water utilities, which have an active coordination group called the Bay Area Emergency and Security Information Collaborative (BAESIC). BAESIC was created after the September 11, 2001 attacks to enable mutual sharing of security-related information, coordination, and undertaking projects and activities to improve mutual security and preparedness. One of these projects was a post-Hurricane Katrina study of Bay Area water needs after a major Hayward Fault earthquake, which demonstrated the need for 2.5 million gallons a day of potable water for three to 30 days to serve a population of 7.69 million.

Recommendations to Improve Resilience

Mr. Wollbrinck provided several recommendations for addressing gaps and needs, including the creation of a Bay Area Emergency Operations Center for critical infrastructure, other essential service providers, local government officials and key stakeholders to coordinate response and recovery activities. (This local, regional EOC would be seamlessly connected to the State-led Coastal Regional EOC, which recently relocated from the Bay Area to Sacramento for budget reasons.) He also recommended a regional emergency fuel distribution plan, development of capabilities to provide utilities with a common operating picture during emergencies, exercises to improve cross-sector coordination and joint response, a procedure to provide emergency regulatory relief, and a "workable" debris management plan.

Steve Dennis, Health and Safety Supervisor / Security Manager / Emergency Response Coordinator, Alameda County Water District

Overview of System

Alameda County Water System has a 103 sq. mile service area serving approximately 330,000 people in the East Bay (Fremont, Newark, and Union City). There are three sources of supply—groundwater (30%), the California State Water Project (50%), and the San Francisco Public Utilities Commission/Hetch Hetchy Water System (20%).

Key Interdependencies and Gaps

The Hayward Fault runs adjacent to ACWD reservoirs and major pipelines. In 2008, the utility hired a consultant to assess system vulnerability to a major earthquake. The study estimated 1,500 to 2,000 pipeline failures leading to a system "bleed-out" in as little as six hours leaving 250,000 residents without water. There would be a loss of surface water supply sources, production facilities shutdown and groundwater supply interruption due to power supply loss. Finding the sources of leaks would not be easy and would take time—weeks to months. It was important to recognize that a catastrophic seismic event will affect all water utilities in the Bay

Area with failed pipelines, interrupted sources of supply, damaged production facilities, and prolonged denial of service.

Existing Efforts to Speed Recovery

Progress has been made to develop regional and statewide water sector collaboration. The BAESIC group has developed key contacts communication directory potable water procurement guidance, and water agencies across the state have created a California Water/Wastewater Agency Response Network (CalWARN), a mutual assistance agreement to deal with major emergencies. This collaboration, however, does not extend beyond water systems to other critical infrastructures and service providers or involve key stakeholder organizations.

Recommendations to Improve Resilience

Steps need to be taken to improve communications capabilities, access to key resources, people, equipment, power, and fuel, and clear access to affect repairs. He concluded by emphasizing the need to have all critical infrastructures and essential service providers working together to address major emergencies and that "the rough stretches can only be done in caravan style." Restoration of water service after a disaster will take much longer without effective working partnerships and coordinated preparedness with interdependent service providers.

Edward Sullivan, Security and Emergency Preparedness, East Bay Municipal Utility District

Overview of System

The East Bay Metropolitan Utility District serves 1.3 million water customers in a 331 sq. mile area that includes 29 cities and communities in two counties. The utility also has 650,000 wastewater customers in an 83 sq. mile area that covers nine cities and communities.

Existing Efforts to Speed Recovery

Over the last ten years it has built and strengthened its infrastructure to withstand earthquake damage and developed operations continuity plans to include resilience. Key dependencies are power, fuel and water treatment chemicals. EBMUD focuses on both horizontal and vertical coordination through the recently created Bay Area Water Multi-Agency Coordination Group, which focuses on providing a common operating picture during pre-disaster planning and during response and recovery, and prioritizing and leveraging limited resources accessible to the members following an event working with the State Emergency Operations Center.

3.5. Breakout Group Discussions

Participants raised a number of significant points in the three concurrent facilitated breakout group discussions held after the first two sessions. These included:

- **The need for service redundancy capacities for power, water, communications, and transportation is a big issue for some smaller communities**.

- **Along with power restoration, expeditious restoration of water service will be a top priority in recovery and regional resilience**. Extended provision of bottled water may be needed for communities across the region, requiring a workable plan for designating points-of-distribution and assuring sufficient supply.

- **Regional recovery planning should address region-wide availability of back-up ATMs, mobile bank branches, and other financial services necessary for business resumption**.

- **A decision-making process with appropriate identified stakeholders needs to be established to assess and prioritize competing needs** of the many jurisdictions, businesses, utilities, community institutions, etc., that will be asking for recovery support, supplies, and other resources.
  - The decision-making process should define who makes the decisions and how they are made, and be able to weigh restoration needs of critical organizations (hospitals, major health clinics, utilities, law enforcement, and fire departments), at risk individuals, debris removal issues, etc., in addressing recovery priorities
  - The role of elected officials in this decision-making process, as well as private sector and other non-government interests, needs to be determined.
  - Regulations and policies that could impede recovery should be identified, including alternatives for regulatory relief or policy revisions. In some cases, waivers or other relief will need to be approved by federal agencies.

- **It is difficult to get organizations to focus on disaster recovery—there are more questions than answers on challenges and what needs to be done.**

- **Various communications work-arounds are being employed by Bay Area organizations**--GETS (land line) and Wireless Priority Cards, satellite communications technology, and HAM radios. Alameda County Water District has an independent two-way radio system with redundant receiver, and Sonoma County has a memorandum of understanding with the San Francisco Section Amateur Emergency Radio Service.
  - The downside of satellite communications is that everyone will be trying to use it at the same time—this was a problem in Haiti where system capabilities became overwhelmed by media users.

- **Providing communications at all levels during the immediate recovery period needs to be addressed** (e.g., among families, between employers and employees, and social service groups and at risk individuals).
  - There are social media tools that can be utilized, e.g., in the San Bruno gas pipeline explosion, people posted information on Facebook. PG&E uses twitter and has a public Facebook page, and could create an employee network page. Organizations are creating independent systems, e.g., there is a Google-sponsored website to look for family members.

- **Steps should be taken to maximize coordination at the neighborhood level and to enable public access to information on post-earthquake damages, outages, and restoration**

status. The USGS earthquake site and ABAG websites could serve as a clearinghouse for this information.

- **Having situational awareness during recovery to provide the necessary common operating picture is essential for utilities, government, and private sector** organizations to have necessary information to make individual and collective decisions about outages, damaged infrastructure, transportation disruptions, and related debris and transportation hazard issues.

- **A Bay Area EOC with representation from critical infrastructures and key resource stakeholders should be established** for response and recovery coordination and decision-making.

- **Closer coordination among utilities and other essential service organizations is necessary for all-hazards preparedness and security**. A coordination group could be established for this purpose.

- **Better risk assessment processes and tools are needed, particularly on a region-wide basis** to address infrastructure interdependencies, vulnerabilities, economic, environmental, and societal consequences, and enable identification of cost-effective mitigation measures.

- **A regional Joint Information Center or some other type of regional mechanism is necessary** for coordinating and disseminating recovery information.

- **Recovery public information planning should prepare people for prolonged service disruptions.** Currently the public's expectations are that basic services will be restored quickly, based on guidance from 72hours.org that they need to be self-sufficient for 72 hours.

- **Individuals need ways and mechanisms to report damages and hazards.** These can be as simple as a Facebook page or website, and can greatly assist emergency responders in how they approach their response.

- **FEMA will "push" resources to those localities best organized to receive them.** There is a need to include private sector organizations in EOCs to undertake and sustain recovery efforts, particularly where provision of essential resources (e.g., fuel, water, construction, and other materials) is required.

- **Tabletops and other types of exercises are good tools for recognizing regional recovery and resilience needs** and fostering cooperation, collaboration, and understanding of regional interdependencies. Regional exercises should be part of a continual preparedness learning process

3.6. Working Lunch Presentation

Brian Klosterman, President & CEO, Nexis Preparedness Systems and Workshop Sponsor, spoke on the importance of pre-event arrangements for emergency supplies as a key element of organizational continuity planning and preparedness. Nexis Preparedness Systems is an

emergency supply management company that provides end-to-end service for managing organizations' emergency preparedness supply processes through calculating resources needed, monitoring expiration dates, and providing for resource rotation and replenishment, and employee preparedness and training. He recounted some lessons learned from his company's work providing businesses, healthcare, schools, and other organizations with such services, such as assessing a company's preparedness supplies and discovering that emergency food was insufficient, or finding out supplies were outdated and could have been donated to charities before they expired.

3.7. Session 3: Transportation – Road, Rail, and Maritime

Tracy Johnson, Manager Seismic Engineering, BART

Overview of System

BART has five lines running 104 miles in a four-county service area and a 360,000 weekday daily ridership. Over 150,000 people cross the Bay on BART each day. During peak commute periods, BART carries as many people as the Bay Bridge. Nearly 20 million trips per year are made by Alameda County residents. BART crosses at least seven earthquake faults and has an aging infrastructure (the system is forty years old). BART's greatest dependency is on power, and it is highly interdependent with PG&E, which has 12 switching stations along the BART track network. The track has a 1 KV electric third rail and is supported by 62 substations and 46 gap breaker stations.

Key Interdependencies and Gaps

Challenges to mitigation efforts include the need to keep sensitive information secure, keeping up with change, and keeping mitigation as a priority in an era of budget constraints. BART until recently has focused mostly on internal continuity needs and is now focusing on building relationships with key stakeholders, sharing emergency response plans, and expanding communications capabilities, including building redundant communication links, to deal with disasters and significant incidents.

Existing Efforts to Speed Recovery

Actions that BART has taken to improve resilience include evaluating interdependencies between BART and PG&E power feeds, examining risks to operations if power is disrupted, and reducing exposure to impacts from power interruptions.

Robert Braga, Caltrans District 4, Division of Maintenance

Overview of System

Caltrans functions as owner and operator of the state and interstate highway system. He added that the California Highway Patrol (CHP) has responsibility and authority for safe travel along state/interstate highways, and is also responsible for security on state routes and facilities. Caltrans District 4 encompasses the nine San Francisco Bay Area counties (population 7.4

million with an area of 8,757 square miles) and has 3,200 employees with an annual operating budget of $490 million to cover 7,600 lane miles of highways, including 420 miles of carpool lanes and seven toll bridges (Antioch, Benicia-Martinez, Carquinez, Richmond-San Rafael, San Francisco-Oakland, San Mateo-Hayward, and Dumbarton).

Key Interdependencies and Gaps

Caltrans dependencies include lifelines and critical facilities for traffic management, including maintenance and traffic operations, and route recovery to capacity, including planning and programming, design, and construction. Critical facilities include 18 bridges, tunnels, and distribution structures. Caltrans core functions and key interdependencies include IT, power, water, sewer, fuels, communications, and contractors and suppliers of construction materials (e.g., asphalt) and heavy equipment. He noted that after the Loma Prieta earthquake, Caltrans strengthened its transportation routes. Caltrans expects to take 72 hours to a week to repair or reroute traffic after a major earthquake, and this will depend on the affected transportation route. Also, to address interdependencies challenges,

Existing Efforts to Speed Recovery

Caltrans has State bulk fuel contracts with flexibility by contract providers to deliver fuel on site, alternate emergency power systems capability at key facilities, onsite generators, ability to "hook-up" portable generator units, and operational redundancy of transportation management centers. Other Districts are structured to handle programming, planning, and design functions if required. Caltrans has multiple communications systems for operational communications: satellite (video/teleconference capabilities), microwave, and 800 MHz systems with extensive redundancy. The Transportation Management Center, which is operational 24/7 and jointly staffed by Caltrans, CHP, and MTC monitors and rapidly deploys available traffic management and motorist information services. Continuing challenges include the need for further coordination with contractors, suppliers, and essential service providers on planning strategies to mitigate and/or address their interdependencies and expanding IT redundancy with minimal funding beyond operational needs. Caltrans is pursuing partnerships with the business community, exploring interdependencies, in order to arrive at "best practices" to mitigate and/or address interdependencies, expanding IT redundancy, and seeking funding for redundancy of operational capabilities and for mitigation of infrastructure interdependencies**.**

LCDR Ken Kostecki, U.S. Coast Guard San Francisco Sector

Overview of System

The USCG has long focused on hurricanes, but has less experience in dealing with other disaster events. The focus after a major earthquake will be on getting individuals and supplies over the water to where they need to go.

Key Interdependencies and Gaps

Dependencies are on fuel and electricity. The USCG has contingencies in place for expediting this mission. It has broad authorities to move cargoes that are critically important and can waive vessel regulations, for example, on passenger limits, or to transport oil. The USCG also has a

role in maritime transportation in assuring national supply chain management in partnership with FEMA, Cal EMA, U.S. Army Corps of Engineers, National Guard, and local governments. The USCG also works with tug and tow companies, local labor organizations, maritime associations, and harbor safety. The gaps the USCG faces are in resource management, lack of interoperability, and personnel transfers that impact available expertise.

Existing Efforts to Speed Recovery

Exercises are an important tool to build preparedness and continuity capacity, and they are looking at ways to enhance coordination. The USCG will work through the State Regional Emergency Operations Center.

3.8. Session 4: Communications and Critical Information Technology Systems

Ken Fattlar, Director of Network Operations, Verizon Wireless

Overview of System

Verizon customers include governments, emergency services, businesses, and individuals. There are three switching stations in the Bay Area. Regulatory Requirements are strict in California. Cell sites must have a conditional use permit. There are air quality regulations that restrict use of generators, hazardous materials (batteries/fuel) requirements, and electromagnetic emissions standards. Major equipment suppliers are Alcatel Lucent, Ericsson, Cisco, and Juniper.

Key Interdependencies and Gaps

Infrastructure dependencies include **e**lectric power (primarily PG&E), transport circuits (the links between cells, switches, and the outside world), and transportation (roads) and fuel (primarily diesel), which is particularly critical. Users who are dependent on Verizon include emergency services, law enforcement, fire, healthcare providers, every other utility, government entities, businesses, and "any customer wanting service."

Existing Efforts to Speed Recovery

Verizon is addressing these challenges through becoming as self-sufficient as possible and practical. All cell sites have batteries and most sites have generators that can provide six to eight hours of power. Providing service requires significant system redundancy, which Verizon addresses with SONET rings, layer 3 routing, and alternate circuit paths. It is building relationships with its key service providers and has mobile back-up systems COWs (cells on wheels), COLTs (cell tower system incorporated in a light truck), GOATs (generator on a trailer to power cell sites), and RATs (repeater and trailer units for radio traffic). Verizon also has emergency microwave systems as well as other resources available on a national scale. In a major earthquake, however, there will be damages to communications infrastructure and a big spike in communications traffic which is a cause for concern. Potential gaps Verizon faces in a major disaster include: gaining situational awareness of immediate post-event conditions (where to deploy COWS and COLTS and where road and other disruptions impede repair); the need for fuel for repair trucks, mobile cell systems, and generators; damages to buildings and limited site

accessibility that impedes repair; power and equipment issues, emergency services priorities, and access to restricted areas. Verizon is also addressing mitigation needs through building cooperative relationships with other communications providers, utilities, and local emergency services, and through its membership in the California Utilities Emergency Association (CUEA). These relationships and having access to a regional EOC are key to Verizon's regional recovery after a major disaster.

Jim Hennessy, National Account Manager, Public Safety, Verizon Wireless, presented several technologies for cell communications connectivity for workshop participants' consideration.

Rakesh Bharania, Network Consulting Engineer, Cisco Systems Tactical Operations

Overview of System

There has been an evolution in people, process, and technologies to support disaster and humanitarian relief from radio and phone systems based on single devices with voice only, and command and control centric at fixed locations to integrated mobile and fixed communications using a wide range of devices carrying voice, video, and data, and systems field deployable anywhere.

Key Interdependencies and Gaps

The critical issue after a disaster is how to "communicate the right information to the right people at the right time." However, the assumption that when a disaster happens, telecommunications will go down is false—the answer is "not always." About 60% of Haiti's telecommunications stayed operational after the 2010 earthquake. The Chile and Japanese earthquake aftermaths show the same situation. The reality is that "everything is IP now—and has been for some time." The internet is just as critical as radio communications; Haiti, for example, was a data-driven response. In Japan's magnitude 9.0 earthquake/tsunami, both IIJ redundant backbone fiber links between Tokyo and Sendai were severed and 20% of Japan's total traffic dropped immediately due to outages. Three of eight fiber links failed to the United States, but good links remained available. The Internet was used heavily by the Japanese public for streaming video and social media, and there was rapid recovery from the event. One of the major Tokyo/Sendai fibers was restored by a day later and all three trans-Pacific fibers were restored by the second day. The reason was that most of Japan's core internet infrastructure was outside of the impacted region. The network continued to work normally outside of the immediate area and was used for emergency information.

Existing Efforts to Speed Recovery

Another example is the San Bruno gas pipeline explosion. There were local communications disruption to cell phones and mobile data services immediately around the affected neighborhood. A mutual aid request to Cisco through the Northern California Regional Intelligence Center (NCRIC) in support of San Mateo County Office of Emergency Services provided communications support to the Incident Command Post. There was GIS support through a Google disaster response team for the National Transportation Safety Board. Overall, the Internet infrastructure in developed countries is highly resilient to disasters at a macro scale

due to redundant links and dynamic routing. At the same time, local disruptions are possible, so it is important to build IT redundancy into organizations.

4. Workshop Additional Outcomes

The following needs and ideas for action were stated by participants during and after the workshop on their attendee evaluations and comment cards.

Utilities/Transportation Interdependencies Impacts and Issues—Need for:

- **More in-depth information and analysis** of second and third-level interdependencies, the extent of damage to equipment, systems, and structures, and realistic timelines for restoration taking interdependencies into account. *(One participant observed that for most organizations there was a "lack of realistic thought" on interdependencies impacts and that "a lot of agencies really think they have some control.")*

- **More detailed information on expected transportation disruption impacts** from major disasters and how information will be conveyed to enable circumventing disruptions from damaged bridges, tunnels, and roadways.

- **Focus on vulnerability of the Bay Area water supplies** from Delta levee failure and flooding from an earthquake or super storm.

- **Examination of communities' and neighborhoods' reliance on utilities, communication, and transportation, and impacts on health and safety and the economy.**
    - Engagement of Community and Neighborhood Emergency Response Teams and other community and social service groups to work with communities on disaster recovery challenges.

Recovery Decision-Making (operational and financial) to Expedite Restoration of Utilities and Transportation—Need for:

- **Information on regional plans for major disaster response and recovery**, including staging and management of resources, how the decision-making process and communications will be handled, and defined roles and responsibilities of federal and state agencies, local government, utilities, private sector, and other key stakeholders.
    - Identification of what decision-making mechanisms exist and what need to be created for restoration prioritization and financing rebuilding.

- **Development of an effective regional resource database** with procedures for making contributions.

Cooperation and Coordination on Interdependency-Related Recovery Issues—Need for:

- **A coordination mechanism** to enable interdependent critical infrastructures and key resource organizations to coordinate activities for preparedness and during disaster recovery.

- **Creation of a Bay Area regional EOC** to interface with the State-led EOC in Sacramento to enable critical infrastructures and other key private sector and government stakeholders to better coordinate for response and recovery. *(Several participants recommended this.)*

- **Development of "shared governance agreements"** to put in place to expedite recovery.

- **Meetings of Emergency Support Function representatives at the State and regional levels** along the lines of FEMA ESF meetings. (This would also apply to Recovery Support Function representatives under the new National Disaster Recovery Framework.)

- **A review of regional recovery plans** to determine what procedures already exist, their "workability" and operational utility, a stakeholder workshop to gain information and discuss operalization of these plans post-disaster, and a regional "clearinghouse" for these plans available to stakeholders. (*A State official noted that there are Regional Catastrophic Earthquake Plans that focus on recovery objectives and discuss coordination structures that are already established and that it would be counter-productive to "recreate something that already exists." A Caltrans representative similarly pointed out that a regional debris management plan already is in place. Non-government participants appeared not to know or were unfamiliar with the content of these and other state and local plans, or if they did, saw them as incomplete or "unworkable," issues that point out the need for state and local officials to brief these plans to the broader stakeholder community.)*

Training and Education to Address Interdependencies Challenges—Need for:

- **Regional recovery and resilience-focused exercises** to raise awareness of vulnerabilities, workability of plans and procedures, and particularly a priority process for restoration, and identification of gaps.

- **Regional recovery interdependencies exercise scenarios** that local governments can use for their stakeholders.

- **Training of officials and stakeholders** in recovery material/equipment protection and scam prevention.

5. Next Steps

The meeting closed with a short discussion of follow-on activities for the Bay Area Disaster Resilience Initiative, including the second Infrastructure Interdependencies Workshop that will focus on remaining critical infrastructure and service providers, and a scenario-based event to further examine regional interdependencies and other recovery-associated needs and capabilities for inclusion in the Action Plan. Workshop I presentations are posted on the ABAG website and that this report summarizing the day's proceedings would be prepared and provided to them. All materials are available at **http://quake.abag.ca.gov/resilience/workshops**.

Appendix A
Workshop Participating Organizations

AAA Insurance Exchange
AC Transit
Adjusters International
AECOM
Alameda County
- Public Health Department
- Sheriff's Office
- Social Services Agency
- Water District

American Red Cross
Amtrak
Association of Bay Area Governments
Bank of America
BARCfirst
Bay Area Center for Regional Disaster Resilience
Bay Area Council
Bay Area Rapid Transit
Bay Planning Coalition
Business Recovery Managers Association
California Department of Public Health, Drinking Water Program
Caltrans
California Emergency Management Agency
California Energy Commission
California Highway Patrol
California Hospital Association
California Resiliency Alliance
Carnegie Mellon University, Silicon Valley
Children's Hospital Oakland
Cisco Systems
City College of San Francisco
City of Clayton
City of Monterey - Police Department
City of Oakland
City of San Ramon
City of Santa Clara
Contra Costa County OES
Contra Costa Voluntary Organizations Active in Disaster
Data911
Degenkolb Engineers
East Bay Municipal Utility District
Eastern Contra Costa Transit Authority
Expert Property Management, Inc.
Exponent
FEMA Region IX
Franklin Templeton Investments
Golden Gate Safety Network
The Greenspan Co.
ICF International
Kaiser Permanente
Laurie Johnson Consulting
Lawrence Livermore National Laboratory
Marin County Sheriff's Office of Emergency Management
Marin Interagency Disaster Coalition
Metropolitan Transportation Commission
Monterey County Office of Emergency Services
Mountain View Fire Department
Pacific Gas and Electric Company
Peralta Community College District
Moffett Park Business Group
National Disaster Resiliency Center
Northern California Regional Intelligence Center (NCRIC)
NetApp
Nexis Preparedness Systems
NICE PACS
Oakland Office of Emergency Services
Peralta Community College District
Port of Oakland
Port of San Francisco
Project Management Institute, San Francisco Bay Area
City and County of San Francisco
- Dept of Emergency Management
- Fire Department Neighborhood Emergency Response Team
- Municipal Transportation Agency

SF Bay Area InfraGard
San Francisco Museum of Modern Art
SF Public Utilities Commission

Wastewater Enterprise
San Jose Water Company
San Mateo County OES
Santa Clara County Fire Department
Santa Clara County Health Care
Santa Clara Valley Transportation Authority
Santa Clara Valley Water District
Sonoma County Fire & Emergency Services
Symantec
Testco
Town of Ross
UC Berkeley School of Public Health
U.S. Army, Presidio of Monterey
U.S. Coast Guard
U.S. EPA Region 9
Urban Resilience Strategies
URS Corp
Verizon Wireless
Wireless Continuity

Appendix B
Planning Team Members

Stephen Baruch	Nexis Preparedness Systems
JoAnna Bullock	Association of Bay Area Governments
Darryl Burton	Business Recovery Managers Association
Steve Dennis	Alameda County Water District
Danielle Hutchings	Association of Bay Area Governments
Gerald Kiernan	Bay Area Center for Regional Disaster Resilience
Catherine Lyons	Bay Area Council
Katie Martinez	San Francisco Public Utilities Commission
Peter Ohtaki	California Resiliency Alliance
Nancy Okasaki	Metropolitan Transportation Commission
George Orbelian	Project Kaisei
Paula Scalingi	Bay Area Center for Regional Disaster Resilience
Monika Stoeffl	
Edward Sullivan	East Bay Municipal Utility District
Kay Vasilyeva	City and County of San Francisco, DEM
Jim Wollbrinck	San Jose Water Company

Appendix C
Breakout Session Questions/
Interdependencies Identification Matrices

1. Looking at past disruptions of energy, water, transportation, and communications/IT systems from disasters and other causes, what were some of the infrastructure interdependencies challenges you saw as the most significant?

2. How would your organization get information to assess the impacts of these disruptions on its service providers, in terms of the magnitude and duration?

3. Which agencies or organizations would you expect to be able to provide this information; how and how soon?

4. What role do you believe utilities and other private sector stakeholders should play with local, state, and federal agencies in recovery efforts to restore services?

5. How is movement of utility restoration resources (personnel and materials) into and out of regions—including cross-state lines—handled and how would these decisions be made?

6. How are recovery and restoration decisions made when they involve interconnected infrastructures and local, state, and federal governments, infrastructure operators, businesses, and community institutions and social services?

7. What dependencies and interdependencies does your organization have with other infrastructures and service providers with focus on those that are of greatest concern?

8. What is your organization doing to address interdependencies challenges?

9. What are priority gaps your organization faces related to gaining information and awareness on, and mitigating potential interdependencies-related impacts affecting disaster recovery?

10. What actions or activities do you feel should be undertaken to address these gaps?

11. What is the level of your organizational dependencies on utilities, transportation, and communications and IT?

MATRIX WORKSHEET 1

Organizational Dependencies and Interdependencies associated with Infrastructures and Essential Service Providers

Taking into account backup systems, systems redundancies, and other contingency measures your organization has, what is the level of your organization's dependencies on utilities, transportation, and communications and IT and how many hours can it operate without these services?

(Please use matrix below to identify the appropriate level and hours.)

	Energy				**Transportation**					
	Electric Power	**Natural Gas**	**Fuels**	**Water Systems**	**Road**	**Rail**	**Maritime**	**Air**	**Public**	**Comm and IT Systems**
Your Organization's Dependencies* ***note your infrastructure or industry:**										
No. of hours your organization can operate without service										

Dependency Level
1 – Low dependency
2 – Moderate dependency
3 – Average dependency
4 – High dependency
5 – Critical dependency *(essential to fulfilling mission or providing goods and services)*

MATRIX WORKSHEET 2

Threats and Interdependencies-Related Impacts

Looking at all-hazard threats, what do you see as the most important in terms of interdependencies-related impacts on utilities, transportation, and communications/IT?

(Please use matrix below to identify level of importance.)

	Energy			Water Systems	Transportation					Comm and IT Systems
	Electric Power	Natural Gas	Fuels		Road	Rail	Maritime	Air	Public	
NATURAL THREATS										
Earthquake										
Tsunami										
Firestorm										
Windstorm										
Pandemic										
Major Flooding										
MAN-MADE THREATS										
Nuclear/Radiological										
Chemical										
Biological										
Technological / Aging Infrastructure Event										

Interdependency Impact

1 – Low impact
2 – Moderate impact
3 – Average impact
4 – High impact
5 – Critical impact *(essential to fulfilling mission or providing goods and services)*

Appendix D
Infrastructure Interdependencies Backgrounder

In the past decade across the nation, the critical infrastructures and other essential service providers that enable our communities to thrive and grow have become increasingly interconnected and interdependent. These infrastructures include energy (electric power, natural gas, fuels); telecommunications, transportation (rail, road, maritime); water and water treatment systems; banking and finance; emergency services; government services; hospitals, healthcare and public health; agriculture and food; commercial facilities; nuclear reactors; materials and waste; dams and levees; manufacturing; chemical facilities; and postal and shipping. To a large degree, this trend towards ever greater linkages has been created by our growing reliance on electronic systems, computer processing and the Internet for managing and operating these infrastructures. This interconnectivity and the resulting interdependencies can exist at multiple levels of increasing complexity and extend beyond a community, a state, and nations, creating unexpected vulnerabilities and significant consequences.

Although emergency and business continuity practitioners are beginning to focus on interdependencies, we remain limited in our understanding of them, the vulnerabilities they create, and how to prevent or lessen their impacts. Disruptions in one infrastructure can cascade, ultimately affecting more than one infrastructure, affecting essential government services, businesses, and individuals in an entire region with far-reaching health and human safety, economic, environmental, and national security consequences.

Examples of Infrastructure Dependencies and Interdependencies

Water and waste water systems, are dependent on a wide range of infrastructures and other essential services, including electric power to run pumps and control systems, petroleum fuels for transportation of repair and maintenance personnel, communications to handle the ordering of chemicals and other supplies and equipment and to direct operations, all modes of transportation for supply and shipping, and financial systems to support billing, payments, and other business services. Likewise electric power utilities depend on natural gas, coal, and petroleum to fuel generators, as well as on road and rail transportation to deliver fuels to the generators, water for cooling and to reduce emissions, and telecommunications to monitor system status and system control, e.g., Supervisory Control and Data Acquisition (SCADA) systems and energy management systems.

Similarly, other infrastructures depend on water and electric power and other infrastructure services.

- Computer, process control, telecommunications, and other systems that run infrastructures depend upon water for cooling. Water systems may require electric power for operating pumps and need logistics and transportation for supplying water treatment chemicals.

- Natural gas fuels critical gas-fired generators in the electric power system. Electric power in turn may be required to operate the critical systems that are essential for delivering gas (e.g., control systems, storage operations, and compressor stations).

- A substation in an electrical distribution system can provide electric power to a key telecommunications switching center, and rail transportation depends on electric power for signaling, crossing protection, monitoring, and other terminal operations. Under certain conditions, failure or loss of power in a substation, for example, directly affects operations at a telecommunications switching center.

- The telecommunications center, in turn, supports SCADA systems for natural gas and oil pipelines, as well as electric power, water, and transportation systems that support electric power.

- Agriculture and food processing, warehousing and distribution, and manufacturing are dependent on all the major infrastructures, for example power for processes and refrigeration, communications for shipping and logistics, all modes of transportation for shipping materials and products, and financial systems to support purchasing of materials and sales of goods.

When infrastructure failures occur and repair crews and replacement components are needed, service providers also depend on other infrastructures, including telecommunications/IT, petroleum fuels (for vehicle and emergency generator fuel), road transportation, and, in some cases, rail transportation. Other dependencies, because of their location or exposure to the environment, are not physically linked but are coupled. A common utility corridor that consists of overhead or underground electric power transmission and distribution lines, underground pipelines, and telecommunications cables dramatically illustrates such dependencies. In many instances, multiple infrastructure assets that are co-located, for example along bridges, roadways, or in a single location, can increase susceptibility to and likelihood of simultaneous outages due to physical hazards, such as a flood, explosion, fire, and earthquake, as well as sabotage.

Another type of dependency can exist in complex systems without a direct link. The failure of a substation, for example, can lead to reconfiguration of the electric network, which, in turn, can overload a similar substation within the system if the demand exceeds capacity. In such cases, a direct link usually does not exist, and the failure occurs only when certain conditions are imposed (e.g., maximum load conditions). Natural hazards, such as earthquakes or extreme weather conditions, clearly show how threats can affect multiple infrastructures at the same time. Such threats also reveal interdependencies that can complicate or delay response and mitigation or recovery of a particular infrastructure from an incident.

Why a Holistic Regional Risk Mitigation Approach is Important

Because these dependencies and interdependencies remain little understood, the emergency management and continuity of operations plans of critical infrastructures, other service providers, and businesses are at best adequate to address localized disasters and not major incidents and disasters with regional consequences, including supply chain disruptions. These plans do not take into account extensive and prolonged impacts that may include disruption or destruction of critical components, systems, and facilities, causing outages of weeks or months, and shortages of supplies, personnel, and capabilities to restore critical services. Such widespread and prolonged service disruptions can cause huge regional economic and psychological impacts that can significantly diminish commerce and cause the relocation of residents in affected communities. At the same time, economic constraints pose additional challenges for states, localities, and stakeholder organizations, which have limited manpower,

funds, and technical expertise to assess all-hazards vulnerabilities from interdependencies, and identify and remedy them.

Whether a natural disaster, manmade incident, or pandemic, there is clearly a need for a holistic regional strategy to improve the resilience of our infrastructures and other essential services, as well as the communities and regions that depend upon them. This all-hazards, multi-jurisdiction, cross-sector approach to preparedness and resilience includes detection, prevention, mitigation, response, recovery/restoration, training, exercises, and community outreach. It requires utilities and other service providers to examine external linkages that affect their operational and business continuity. It also necessitates bringing together local public, private, and non-profit stakeholders with state and federal partners in collaboration to share information and understand and address regional vulnerabilities and consequences posed by infrastructure interdependencies.