

Long-Term Infrastructure Systems Recovery

Infrastructure damage in a disaster can lead to damage to other systems and delayed recovery.

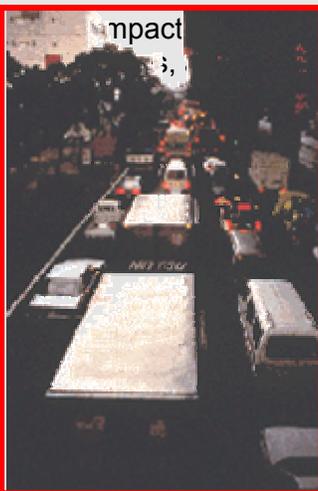
Infrastructure systems include water and wastewater, transportation (including airports), power, and communications lifelines. In 2005, the Hurricane Katrina Disaster on the Gulf Coast has reinforced existing knowledge on the role of infrastructure before and after disasters.

(1) Infrastructure systems, including roads and highways, ports and airports, pipelines carrying water, sewage, and natural gas, as well as power and communications systems are all interconnected.

(2) Infrastructure is critical to a safe and resilient economy and infrastructure disruptions can lead to disproportionate economic impacts on the business community.

(3) Infrastructure interdependencies can lead to cascading failures of interrelated infrastructure systems with impacts far larger than the impacted area.

(4) People who are impacted if infrastructure is damaged are disproportionately the young, the elderly, and those with special needs.



Impact in most large
rms.

Emergency and
utility repair vehicles
caught in the
gridlock following the
Kobe, Japan,
earthquake.

Infrastructure systems need to work together to increase the resiliency and speed recovery of these systems.



Roadways
flooded in
Hurricane
Katrina

Cities, counties, transit districts, water suppliers, wastewater system operators, PG&E, telecommunications operators, and other utilities have been working independently on hazard mitigation, emergency response, and continuity of operations (or business continuity), and disaster recovery planning for their individual organization.

In addition, each type of infrastructure provider has been holding coordination meetings with the other providers of their type of infrastructure and with CalEMA. For example, transit agencies work with the Metropolitan Transportation Commission (MTC) on transit disaster response coordination, while water agencies work together on coordination.

While all of these agencies have participated with the Golden Guardian and Silver Centennial regional disaster **response** exercises, and many are jointly participating in the regional multi-jurisdictional Local Hazard **Mitigation** Plan, the ways in which these agencies can best collaborate in disaster **recovery** are just now being initiated. Such cooperation is particularly important due to the large number of organizations involved and the system recovery interdependencies.

Bay Area transportation and utility facilities and networks are vital lifelines during and following disasters, as well as in the functioning of our region and its economy. This issue paper is one of eight discussing long-term recovery planning issues that will continue beyond 60 or 90 days after a major regional disaster.

Lifeline System Interdependencies and Disaster Recovery

One of the main reasons for the interdependencies of infrastructure systems is that they tend to be geographically located in the same areas. For example, water, sewer, and natural gas pipelines tend to be under local roads. Communications and electrical cables are either located under those roads or adjacent to them. All have similar exposures to hazards that are related to serving the developed portions of the region. Most of these agencies also understand that one of the most critical areas of interdependencies is the Delta.

In addition to geographic interdependencies, lifeline systems also have system interdependencies. Examples include the relatively flexible use of the transportation system (because of alternate available routes) to deliver water treatment chemicals to a

water treatment facility and the short-term relatively inflexible use of the electric power system (due to lack of alternative power lines) to run pumps at that water treatment facility.

In addition to identifying geographic and system interdependencies, these analyses need to address the length of time required to restore various services to a level adequate for recovery. The length of time of a disruption increases the impacts. However, typically, doubling the time of disruption more than doubles the impacts. In addition, the disruption of one infrastructure system delays the recovery of other systems because the infrastructure systems are not available. Thus, speeding recovery of infrastructure systems and focusing on interdependencies of those systems is critical.¹

The following linkages between the water supply systems and other infrastructure lifeline systems are critical:

Water ◀-▶ Transportation –

(◀ = needed by water from transportation; ▶ = needed from water by transportation)

- ◀-▶ Co-location hazard exposure of distribution pipelines beneath roads
- ◀ Transport of repair and maintenance vehicles to locations for repairing pipelines
- ◀ Transport of repair, customer service, and operations facility crews to-and-from their homes
- ◀ Delivery of chemicals to water treatment facilities
- ◀ Delivery of fuel to run critical facilities
- ◀ Delivery of emergency drinking water in bags to customers at emergency distribution points
- ▶ Water for concrete construction and dust control

Water ◀-▶ Telecommunications –

(◀ = needed by water from telecommunications; ▶ = needed from water by telecom)

- ◀-▶ Co-location hazard exposure of distribution pipelines beneath roads with cable and underground wiring; above ground networks also aligned with roads (and thus pipeline corridors)
- ◀ Automated systems and process control equipment for treatment and operations
- ◀ Communication with repair and maintenance crews
- ◀ Communication with customers for repair and maintenance requests
- ◀ Emergency communications with emergency operations centers
- ▶ Water for communication equipment cooling systems

Water ◀-▶ Petroleum, natural gas, and electrical systems –

(◀ = needed by water from energy systems; ▶ = needed from water by energy systems)

- ◀-▶ Co-location hazard exposure of natural gas and some other fuel lines beneath roads, as well as electric power lines both beneath and adjacent to road corridors
- ◀ Gasoline and lubricants for use in repair and maintenance vehicles repairing pipelines
- ◀ Gasoline and lubricants for vehicles of repair, customer service, and operations facility crews to-and-from their homes
- ◀ Electric power for pump and lift stations, treatment plant operations, and control systems

¹ See, for example, Peerenboom, J., Fisher, R., and Whitfield, R., 2001. "Recovering from Disruptions of Interdependent Critical Infrastructures" presented at the *CRIS/DRM/IIIT/NSF Workshop on Mitigating the Vulnerability of Critical Infrastructures to Catastrophic Failures* Lyceum, Alexandria, Virginia.

- ◀ Fuel to run back-up generators at some critical facilities
 - ▶ Water for refinery production, pumps, compressors, cooling, emissions reduction, and fire suppression
 - ▶ Water for electric power plant operations, including cooling and emissions reduction
- The following figure shows these linkages.

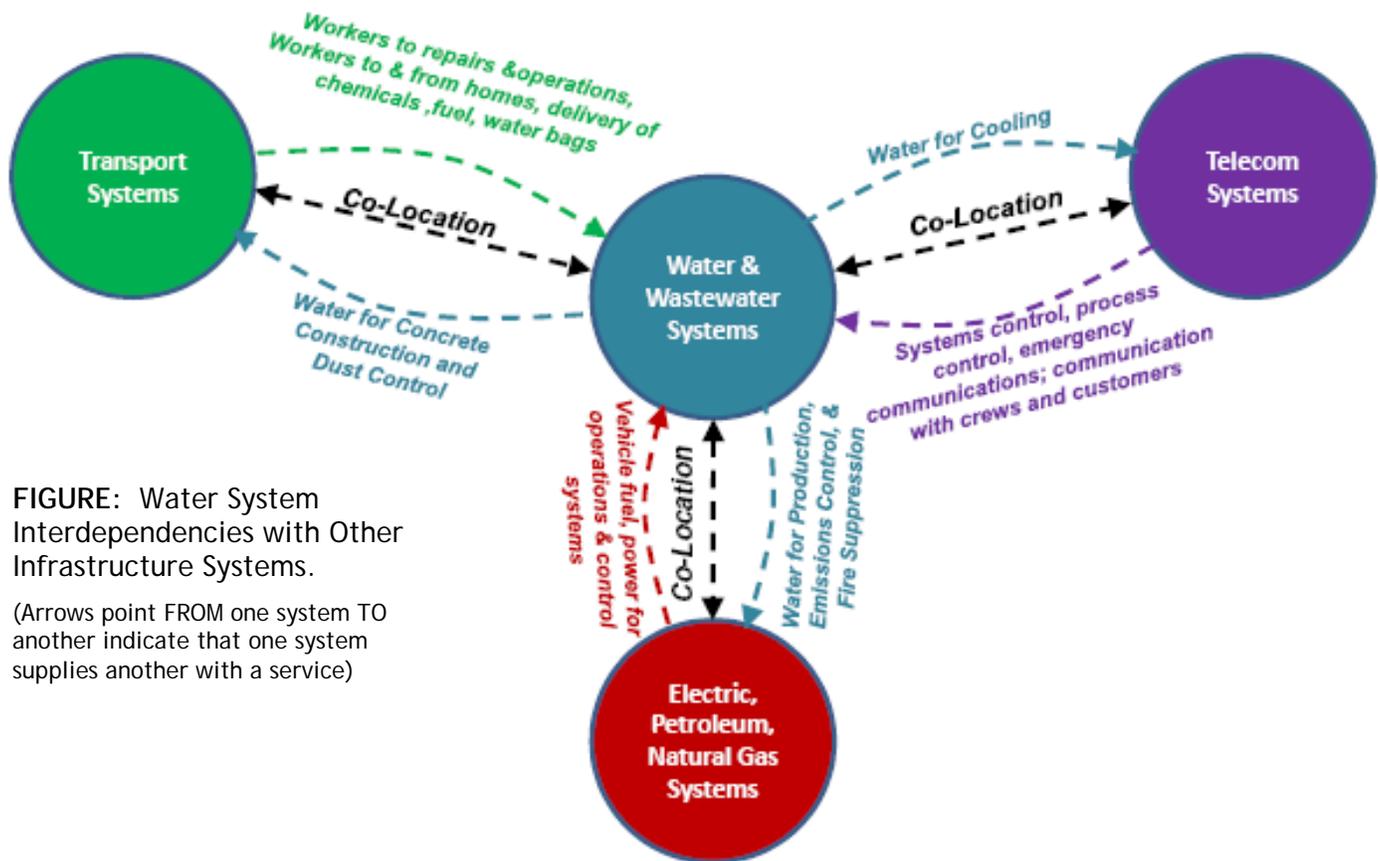


FIGURE: Water System Interdependencies with Other Infrastructure Systems.

(Arrows point FROM one system TO another indicate that one system supplies another with a service)

The following linkages between transportation systems (including airports) and other lifeline systems also are critical:

Transportation ◀-▶ Water – (repeated for completeness)

- ◀-▶ Co-location hazard exposure of distribution pipelines beneath roads
- (◀ = needed by transportation from water; ▶ = needed from transportation by water)
- ◀ Water for concrete construction and dust control
- ▶ Transport of repair and maintenance vehicles to locations for repairing pipelines
- ▶ Transport of repair, customer service, and operations facility crews to-and-from their homes
- ▶ Delivery of chemicals to water treatment facilities
- ▶ Delivery of fuel to run critical facilities

Transportation ◀-▶ Telecommunications –

- (◀ = needed by transportation from telecommunications; ▶ = needed from transportation by telecom)
- ◀-▶ Co-location hazard exposure of cables and underground wiring beneath roads or along roads
- ◀ Automated systems and process control equipment for trains
- ◀ Communication between transit operators and bus/train drivers
- ◀ Communication with repair and maintenance crews of roads, ports, and airports
- ◀ Communication with people needing to travel to and from work (or using airports and ports)
- ◀ Emergency communications with emergency operations centers
- ▶ Transport of repair and maintenance vehicles to locations for repairing cables, wires, and equipment

- ▶ Transport of repair, customer service, and operations facility crews to-and-from their homes
- ▶ Delivery of replacement specialized equipment to critical facilities

Transportation ◀-▶ Petroleum, natural gas, and electrical systems –

(◀ = needed by transportation from energy systems; ▶ = needed from transportation by energy systems)

- ◀-▶ Co-location hazard exposure of natural gas and some other fuel lines beneath roads, as well as electric power lines both beneath and adjacent to road corridors
- ◀ Gasoline and lubricants for use in road and highway repair and maintenance vehicles
- ◀ Gasoline & lubricants for buses & vehicles of repair & operations facility crews to-and-from their homes
- ◀ Electric power for train operations, some buses, street lights, gas station pumps, credit card machines, and control systems
- ◀ Fuel to run back-up generators at some critical operations facilities
- ▶ Transport of repair and maintenance vehicles to locations for repairing pipelines, power lines, & equipment
- ▶ Transport of repair, customer service, and operations facility crews to-and-from their homes
- ▶ Delivery of fuel to gas stations and delivery of replacement equipment to refineries and critical facilities

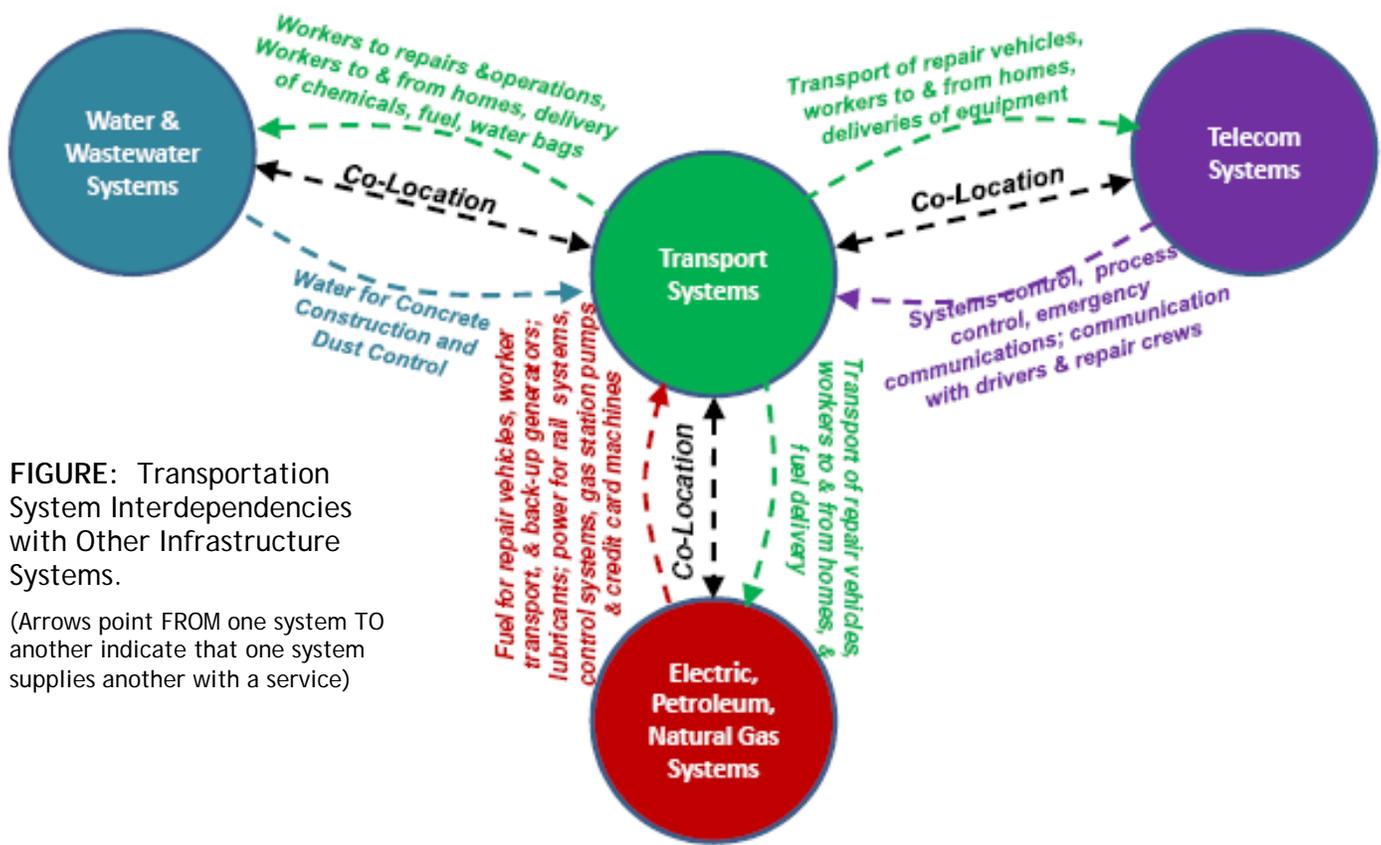


FIGURE: Transportation System Interdependencies with Other Infrastructure Systems.

(Arrows point FROM one system TO another indicate that one system supplies another with a service)

Combining these two figures creates a more complete picture of the interdependencies of water and transportation systems (typically managed by local governments) than the original Peerenboom and others (2001) figure, even though the distinctions among natural gas, electric power, and oil are not highlighted. This combined figure is shown below.

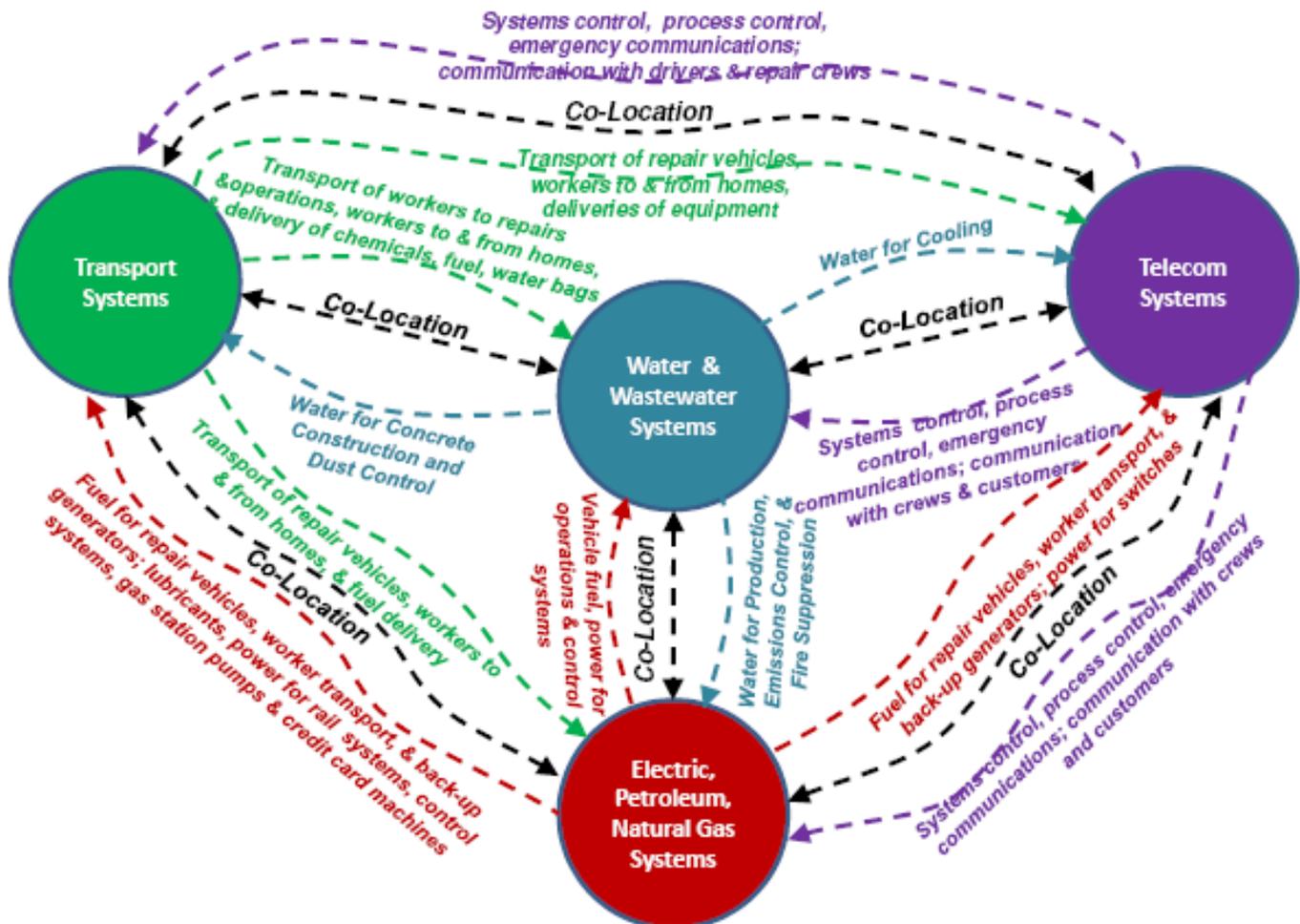


FIGURE: Transportation System Interdependencies with Other Infrastructure Systems.

(Arrows point FROM one system TO another indicate that one system supplies another with a service)

Interrelationships with electrical, natural gas, and telecommunications systems

For most of the Bay Area, both gas and electricity is provided by the Pacific Gas and Electric Company (PG&E), a private utility.

PG&E's electric customers should expect to be without power for 72 to 96 hours. However, this ambitious recovery plan means that the company needs to have pre-established protocols with city and county public works and water agencies so that trenches are excavated once.

On the other hand, gas lines are likely to be out for weeks. The company views the principal issues are likely to be transportation of workers to locations of broken lines, as well as getting customers able to reestablish their businesses.

Telecommunications facilities and equipment are the most resilient of the infrastructure systems and are expected to return to service most rapidly.

Ideas for Cooperative Action and Expected Priority Setting

One critical link with cities and counties is that both local governments and infrastructure providers need to better understand what each can do to help the other recover more quickly and efficiently. The following recommendations have been developed with the goals of encouraging mitigation and disaster preparedness before disasters, as well as to speed up long-term recovery after disasters.

In the case of emergency response and short-term recovery, decisions are likely to be made by senior infrastructure agency staff in individual agency Emergency Operations Centers with little or no elected official policy advice. At this time, the plan is for a Regional Recovery Authority to be appointed by the Governor to be up and running as soon as possible to make policy decisions, particularly related to allocation of limited resources. For example, in the case of transportation, the priorities will likely be bridges, fixed rail, access to ports and airports, providing access to worst damaged areas, and providing access between less damaged areas. Transbay bridge **approaches** may take up to 90 days to fix even if bridge itself is functional. Ports and airports will continue to have damage 90 days out; the goal will be to make at least one airport and one port operational, assuming resources will need to be prioritized and will need to rely on the Regional Recovery Authority to make those tough policy decisions.

Actions Focusing on Infrastructure Facilities Owned by Cities and Counties	Regional Priority	Responsible Agency
A – 1: Assess the vulnerability of critical infrastructure facilities owned by cities and counties to damage in natural disasters and make recommendations for appropriate mitigation. (LHMP Mitigation Strategy INFR a-1)	Existing program, under-funded	City and county public works, port, and airport personnel
A – 2: Retrofit or replace critical infrastructure facilities owned by cities and counties (and/or their back-up facilities) that are shown to be vulnerable to damage in natural disasters. (LHMP Mitigation Strategy INFR a-4)	Existing program, under-funded	City and county public works, port, and airport personnel
A – 3: Ensure that critical intersection traffic lights function following loss of power by installing battery back-ups, emergency generators, or lights powered by alternative energy sources such as solar. Proper functioning of these lights is essential for rapid evacuation, such as with hazmat releases resulting from natural disasters. (LHMP Mitigation Strategy INFR a-9)	Existing program, under-funded	City and county public works departments
A – 4: Clarify to workers in critical facilities and emergency personnel, as well as to elected officials and the public, the extent to which the facilities are expected to perform only at a life safety level (allowing for the safe evacuation of personnel) or are expected to remain functional following an earthquake. (LHMP Mitigation Strategy INFR b-9)	Existing program	Cities, counties, regional agencies, and all infrastructure providers
A – 5: Expedite the funding and retrofit of seismically-deficient city- and county-owned bridges and road structures by working with Caltrans and other appropriate governmental agencies. (LHMP Mitigation Strategy INFR b-1)	Existing program, under-funded	Public works departments of cities and counties
A – 6: As an infrastructure operator, designate a back-up Emergency Operations Center with redundant communications systems. (LHMP Mitigation Strategy INFR a-21)	Existing program, under-funded	Emergency management agencies of cities and counties who are infrastructure providers

Actions Related to Sharing Knowledge of Infrastructure Facilities Owned by Special Districts and Companies	Regional Priority	Responsible Agency
B – 1: Ensure that critical buildings owned or leased by special districts or private utility companies participate in a program similar to San Francisco’s Building Occupancy Resumption Program (BORP). The BORP program permits owners of buildings to hire qualified engineers to create facility-specific post-disaster inspection plans and allows these engineers to become automatically deputized as City/County inspectors for these buildings in the event of an earthquake or other disaster. This program allows rapid reoccupancy of the buildings. Note - A qualified engineer is a California licensed engineer with relevant experience. (LHMP Mitigation Strategy INFR f-1)	Existing program	City and county building departments
B – 2: Ensure that plans of water and wastewater agencies for speeding the repair and functional restoration of water and wastewater systems are communicated to local governments and owners of other critical infrastructure systems. If water and wastewater agencies have not yet developed such plans, encourage them to do so. (related to LHMP Mitigation Strategy INFR a-6)	Existing program	Water and wastewater agencies with cities and counties
B – 3: Pre-position emergency power generation capacity (or have rental/lease agreements for these generators) in critical buildings of cities, counties, and special districts to maintain continuity of government and services. (LHMP Mitigation Strategy INFR a-8)	Existing program, under-funded	Infrastructure providers with cities and counties
B – 4: Minimize the likelihood that power interruptions will adversely impact lifeline utility systems or critical facilities by ensuring that they have adequate back-up power. (LHMP Mitigation Strategy INFR a-11)	Existing program, under-funded	Infrastructure providers with cities, counties, and regional agencies

Actions Related to Providing Information to Businesses and Residents About Disaster Recovery	Regional Priority	Responsible Agency
C – 1: Before disasters, provide materials to the public related to planning for power deficiencies and restrictions. After a disaster, provide materials for addressing those power deficiencies and restrictions, as well as on expected time frames for power restrictions and restorations. (related to LHMP Mitigation Strategy INFR g-1)	Existing program	Power suppliers with cities and counties
C – 2: Before disasters, provide materials to the public related to family and personal planning for delays due to traffic or road closures, or due to transit system disruption caused by disasters. After disasters, keep joint transportation communication flowing to the public in a consistent and appropriate manner, stressing what is in operation, not just what is closed, using appropriate graphics. (related to LHMP Mitigation Strategy INFR g-2)	Existing program	Transportation agencies with cities and counties
C – 3: Before disasters, provide materials to the public related to coping with reductions in water supply or contamination of that supply BEYOND regulatory notification requirements. After disasters, keep communication flowing to the public in a consistent and appropriate manner, stressing what is in operation, not just what is disrupted, using appropriate graphics. (related to LHMP Mitigation Strategy INFR g-3)	Existing program	Water suppliers with cities and counties

C – 4: Before disasters, provide materials to the public related to coping with disrupted storm drains, sewage lines, and wastewater treatment (such as materials developed by ABAG's Sewer Smart Program). After disasters, keep communication flowing to the public in a consistent and appropriate manner, stressing what is in operation, not just what is disrupted, using appropriate graphics. (related to LHMP Mitigation Strategy INFR g-4)	Existing program	Sewer agencies with cities and counties
C – 5: Both before and after disaster, and continuing into the long-term recovery period, develop and distribute appropriate materials for access and functional needs populations related to hazard mitigation, emergency preparedness, and disaster recovery, such as those on the http://www.preparenow.org website related to infrastructure issues. (related to LHMP Mitigation Strategy INFR g-7)	Existing program	All infrastructure providers with cities and counties

Actions Related to Regional Long-Term Recovery Planning	Regional Priority	Responsible Agency
D – 1: Set regional long-term recovery goals, ensuring that the recovery goals of infrastructure providers are consistent with the goals and expectations of other infrastructure providers and those of cities and counties, and of the public.	Funding being sought	Regional agencies with infrastructure providers, cities and counties
D – 2: Do table-top and other exercises focusing on 60-120 days after a disaster jointly with infrastructure providers and cities and counties to identify critical interdependencies through, for example, scenario planning.	Funding being sought	Regional agencies with infrastructure providers, cities and counties
D – 3: Work to establish mechanisms for a Regional Recovery Authority to establish priorities for use of recovery funds.	Funding being sought	Regional agencies with infrastructure providers, cities and counties
D – 3: Work to develop a systems analysis for short- and long-term recovery of the regional airport system, including both international and general aviation airports.	Funding being sought	Regional agencies with airport operators, cities and counties

NEXT STEPS FOR ABAG –



These issues were initially discussed at the Regional Planning Committee (RPC) meeting in December 2008. For those strategies noted as being in the multi-jurisdictional Local Hazard Mitigation Plan, priorities were approved by RPC in August 2009, as well as by ABAG's Executive Board in September 2009.

ABAG is committed to regional long-term recovery planning, as well as looking at ways to involve ABAG's Regional Planning Committee and the Bay Area Council in this process. ABAG's role is one of fostering collaborative and interdependency planning of infrastructure providers.

CREDITS – Prepared by Jeanne Perkins with assistance from Danielle Hutchings.

PHOTO CREDITS – Page 1 (left) – Sarah Nathe and CalEMA; Page 1 (right) – BBC.