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Resilient Washington State: Final Workshop Report

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Synthesis of Resilient Washington State Workshops and Sector Meetings

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Introduction

The Workshop on December 2

The final Resilient Washington State Workshop was held on December 2, 2011. This one-day event allowed participants to review and contribute additional information to the assessments that the four sector groups (*Critical Services*, *Utilities*, *Transportation*, and *Housing and Economic Development*) had developed during the preceding year. The workshop was intended to wrap up the work of the sector groups by giving participants the chance to:

- Compare the estimated and desired recovery timeframes that each group proposed.
- Discuss conflicts in the results and the interdependencies of the sectors.
- Revise estimated recovery times and any notes that explained or qualified the estimates.
- Propose and discuss recommendations for achieving recommended resiliency targets.

The results of the workshop will be used by the Resilient Washington State (RWS) Subcommittee to develop the state Seismic Safety Committee's final report and, ultimately, policy recommendations for agency and legislative action.

Purpose and Background of the Resilient Washington State Initiative

As research over the past several decades has shown, the earthquake hazard in our state is very high. A recent FEMA study of estimated losses from earthquakes now ranks the state of Washington second in the nation for highest earthquake risk (*FEMA 366/April 2008*). Moreover, because all regions of the state are interconnected—economically, socially, and even physically through shared systems and resources—a destructive earthquake in one part of the state can have serious and long-lasting consequences for the others.

> *"The annualized loss from earthquakes nationwide is estimated to be $5.3 billion per year, with California, Oregon and Washington accounting for $4.1 billion, or 77 percent" (FEMA 366/April 2008).*

To address this hazard, the Washington State Seismic Safety Committee initiated the Resilient Washington State Initiative. Its purpose is to provide a framework for improving Washington's resilience when earthquakes occur by proactively reducing critical vulnerabilities before the next damaging incident. Such a framework includes recommendations for legislation and other measures that will encourage pre-earthquake planning, mitigation, and enhanced seismic performance of future construction to lower seismic risk and reduce the time it takes to recover from a significant earthquake. The framework is intended to facilitate long-term implementation of seismic risk reduction policies and activities across the state with the goal of making the state resilient in a 50-year timeframe.

RESILIENCE DEFINED

To shape the initial direction of the project, the Resilient Washington State (RWS) Subcommittee surveyed the existing literature and found numerous definitions of the term *resilience*—none of which were suitable for this initiative. Ultimately, the RWS Subcommittee formulated a definition of resilience that can be applied to the state as a whole:

> ***A resilient state is one that maintains services and livelihoods after an earthquake. In the event that services and livelihoods are disrupted, recovery occurs rapidly, with minimal social disruption, and results in a new and better condition.***

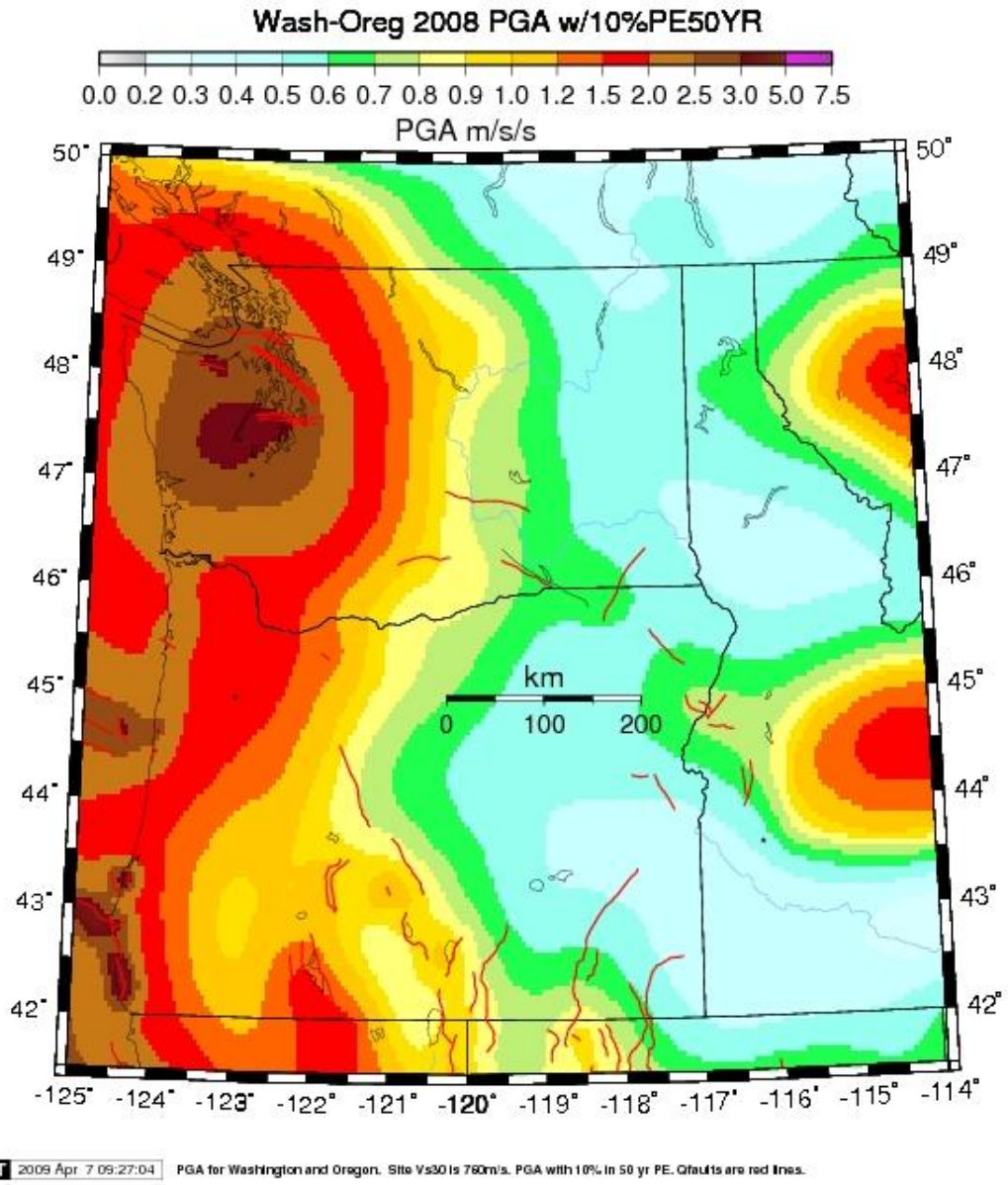
The subcommittee also articulated a set of equally-weighted values to help guide participants as they identified potential recovery targets. These are (in no particular order):

- *Life Safety and Human Health:* Residents of the State of Washington should not suffer life-threatening injuries from earthquake-induced damage or develop serious illness from lack of emergency medical care after an earthquake. This includes enforcing and updating building codes, eliminating non-structural hazards, and ensuring continuity of emergency health care.
- *Property Protection:* Public and private property within the State of Washington should be built, retrofitted, or rebuilt to minimize earthquake-induced damage. This includes proper design and construction of both structural and non-structural elements.
- *Economic Security:* Residents and businesses within the State of Washington should have access to income opportunities to meet basic needs before and soon after an earthquake. This includes sufficient employment opportunities, market access, distribution capacity, and supplier access.
- *Environmental Quality:* The natural resources and ecosystems of Washington State should be managed in such a way as to minimize earthquake-induced damage. This includes the use of proper growth management, accident response capacity, and industrial safety measures.
- *Community Continuity:* All communities within the State of Washington should have the capacity to maintain their social networks and livelihoods after an earthquake disaster. This includes prevention of social-network disruption, social discrimination, and community bias.

DEFINING THE "EXPECTED" EARTHQUAKE(S) FOR THIS PROJECT

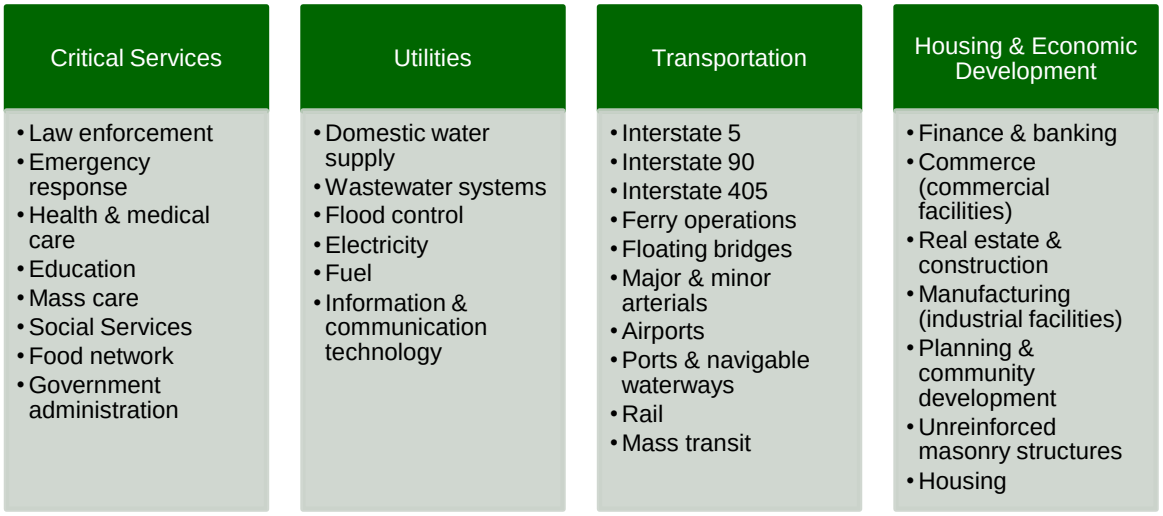
For the purposes of defining resilience and developing mitigation policies to achieve it, the RWS Subcommittee directed that sector group participants adopt a two-pronged approach to the expected earthquake ground motions. The first approach was to consider a series of scenario

earthquakes that had been defined for the State of Washington in 2009. Participants were to use these scenarios to comprehend the geographic area of impact of a single earthquake, with the understanding that only a single scenario happens at one time. These expected-earthquake scenarios are consistent with the USGS National Seismic Hazard Maps, even though they represent a single event and some may occur more frequently than others. The second approach was to consider peak ground accelerations (PGA)—defined by the USGS as having a 10% probability of exceedance (10/50)—for the state. These are shown on the following map:



Assessing the Resilience of Washington's Infrastructure

For organizational purposes, the state's systems and infrastructure were divided into four key sectors: *Critical Services*, *Transportation*, *Utilities*, and *Housing and Economic Development*. These sectors were further subdivided into their primary components. This organization provided the basic structure for all discussions about and assessments of Washington's capacity to recover from an earthquake.



To ensure a full and balanced assessment, the RWS Subcommittee solicited input from a wide range of experts and stakeholders from across the state and from all four sectors. The participants in this project included representatives from local, state, and federal agencies, university departments, and private businesses.

The subcommittee began gathering input at a one-day kick-off workshop on September 17, 2010. Forty-five people attended and participated in discussions that further refined the values and shaped the way the sectors and components were defined.

Following this initial workshop, four workgroups were formed, one for each of the sectors. These groups, which included many of the people who had attended the workshop, met from spring through fall of 2011. The members of the sector groups used their collective expertise to:

- Evaluate the current condition of the state's systems and infrastructure to determine how they will hold up in an earthquake and how quickly they can be restored if disrupted or damaged.
- Define the desired levels of performance and develop target timeframes for the restoration of services and functions following an earthquake.

- Define the vulnerabilities and key interdependencies of each sector. (For example, when considered alone, the food network might be restored within a week to a month, but its recovery depends on the restoration of the transportation system, which could take longer than three months.)
- Propose recommendations for statewide action to achieve desired targets.

THE ROLE OF THE FINAL WORKSHOP ON DECEMBER 2, 2011

At the concluding *Resilient Washington State Workshop* on December 2, 2011, the co-chairs of the sector groups presented the results of each groups' efforts. The experts and stakeholders who participated in the final workshop were then invited to take part in breakout sessions to review and, if necessary, revise the assessments. In particular, the participants were asked to capture the ways in which the interdependencies of the sectors and components might impact and alter the timeframes required for recovery.

The results of the workgroups and the modifications made during the workshop on December 2, 2011 are summarized in the tables and notes in the following report. The tables and notes are intended to serve as tools for shaping the direction of earthquake planning, mitigation, and response and the development of policies that will improve statewide resilience.

Critical Services Sector

The following table provides a summary of the estimated timeframes for recovery of key components of the infrastructure, systems, and services of the Critical Services sector in the state of Washington. The Xs indicate the sector group's best educated guess regarding the current timeframe for the response and recovery of each component and subcomponent after a scenario earthquake. The colored areas represent the goals or targets for each component and subcomponent. (These targets indicate the recovery timeframes that are necessary to achieve resilience in the state of Washington.) The gaps between the Xs and the colored areas reveal the need for further evaluation, policies, and actions to improve Washington's resilience.

KEY TO THE TABLE

TARGET TIMEFRAME FOR RECOVERY:

Operational (time it ought to take to restore component to 80-90% operational):*	
TIME NEEDED FOR RECOVERY TO 80-90% OPERATIONAL GIVEN CURRENT CONDITIONS:	×

For a number of components, the timeframes marked in the table reflect the estimated recovery period following a worst case scenario earthquake. See the notes following the table for details.

TARGET STATES OF RECOVERY: WASHINGTON'S CRITICAL SERVICES SECTOR

	Event occurs	0–24 hours	1–3 days	3–7 days	1 week–1 month	1 month–3 months	3 months–1 year	1 year–3 years	3 + years
Law enforcement				×					
Emergency response				×					
Health and medical care							×		
Education							×		
Mass care					×				
Social services						×			
Food network					×				
Government administration					×				

Law Enforcement

Law enforcement in this context refers to the emergency response and regular policing duties of local and state law enforcement agencies.

Target timeframe for response and recovery: 3–7 days

Anticipated timeframe based on current capacity: 3–7 days

The actual response and recovery time will depend on a number of factors. For example:

- Effective response depends on whether or not the communications system is functioning following the earthquake. (This may depend in part on the functionality of backup generators.)
- The number of law enforcement personnel who are able to report to work may be limited by such factors as the state of the transportation system and where personnel were at the time of the earthquake.
- The availability of vehicles and fuel may be limited due to earthquake damage.
- Law enforcement facilities (including prisons) and equipment may be damaged by the earthquake or secondary effects.
- Transportation corridors (such as roads and bridges) in damaged areas will have to be repaired. It will also take time to identify and clear alternate routes.
- The response and recovery timeframe is likely to be shorter if agencies maintain up-to-date pre-disaster plans and have trained personnel to implement them.
- Mutual aid agreements between counties may facilitate a quicker response and shorten the recovery timeframe.
- The community's level of trust in law enforcement prior to the earthquake is likely to influence the effectiveness of law enforcement after the event. Likewise, the increased stress and feelings of vulnerability that develop in a population within the first few days of a disaster will impact people's perceptions of law enforcement.

A recovery period of 3–7 days was considered realistic for this component due to the amount of time required to gather agency personnel, clear critical transportation routes, and resolve problems resulting from damage to law enforcement facilities and equipment.

After an earthquake, the first priority of law enforcement personnel will be life saving and live sustaining actions, rather than regular policing. This means that emergency-specific law enforcement activities will constitute the first stage of the recovery of this component, with law enforcement officers working alongside other emergency responders. Because the earthquake scenarios being considered are serious enough to prompt a presidential disaster declaration, it is

likely that the National Guard will be mobilized to assist with security. Regular policing duties will be resumed as the recovery proceeds. It may be some time, however, before the community's feeling of pre-earthquake security is restored.

RECOMMENDATIONS

- Identify, review, and update the disaster response plans of law enforcement agencies. As part of this process, make sure that law enforcement personnel are familiar with and trained to implement these plans. Reassess disaster response plans annually.
- Identify, review, and encourage further development and expansion of mutual aid agreements to help facilitate the sharing of resources and personnel. Reassess these agreements annually. Also, take steps to increase awareness of existing mutual aid agreements (local, county, state, and federal).

National Security

The response and recovery of facilities and services related to national security were not specifically included in the estimated recovery period for local and state law enforcement.

Issues related to national security include:

- Safety and continuity of operations at military bases such as Joint Base Lewis-McChord and the U.S. Naval Submarine Base at Bangor. Among other things, this will depend on whether buildings are constructed or retrofitted to withstand expected earthquakes.
- The development of redundancy in key systems and functions of Washington's military bases to ensure minimal disruption of national systems.
- Border security, particularly in the days immediately following an earthquake that disrupts normal security operations along the Canadian border or that reduces Coastguard patrols along Washington's coast.
- The ability of the Hanford nuclear-power plant and reservation to withstand the effects of an earthquake and remain both safe and secure.

While the resilience and recovery of such facilities and services are matters of concern, these must be addressed at a national level, with input from relevant agencies and authorities, including the Department of Defense and U.S. Department of Homeland Security.

Emergency Response

Emergency response in this context refers to all first responders, including urban search-and-rescue teams, fire fighters, and emergency medical technicians (EMTs). This component also includes emergency operations centers (EOCs) and critical response systems, non-profit aid

organizations (such as the American Red Cross), emergency morgue facilities, and Hazmat crews.

Target timeframe for response and recovery: 1–3 days
Anticipated timeframe based on current capacity: 3–7 days

The actual response and recovery time will depend on a number of factors. For example:

- The more extensive the damage and the greater the number of fires that result from the earthquake, the greater the demand will be on limited resources and personnel.
- Some fire stations and other emergency response facilities and equipment may be rendered inoperable by the earthquake or secondary effects.
- If local water systems are damaged, water may not be available for firefighting.
- The number of local emergency response personnel who are able to report to work may be limited by such factors as the state of the transportation system and where personnel were at the time of the earthquake.
- Mutual aid agreements between counties may facilitate a quicker response and shorten the recovery timeframe.
- It will take time to manage debris, restore transportation corridors (such as roads and bridges), and identify alternate routes. How much time is needed will depend on factors such as geographic location and the extent of the damage.
- Qualified building inspectors must be available to certify that buildings are safe to use.

Although many aspects of emergency response will be initiated within the first 24 hours, a period of 1–3 days is realistic given the length of time needed to:

- Staff state and local emergency operations centers.
- Mobilize urban search-and-rescue teams and transport them into the disaster area.
- Coordinate with military bases to establish alternate means of transporting personnel, equipment, and pharmaceutical supplies from outside the disaster area.
- Find headquarters for aid organizations such as the American Red Cross.

In rural areas and small cities, emergency response may take longer than in the larger urban areas because the resources of rural areas tend to be more limited. Rural counties and small cities will be particularly reliant on pre-existing mutual aid agreements with other communities across the state.

RECOMMENDATIONS

- Identify, review, and encourage further development and expansion of mutual aid agreements to help facilitate the sharing of resources and personnel. Reassess these agreements annually. Also, take steps to increase awareness of existing mutual aid agreements (local, county, state, and federal).
- Seismically retrofit all fires stations located in vulnerable areas.
- All jurisdictions, regardless of size, should develop, exercise, and update annually robust continuity of operations plans, including the ordering and deployment of requested resources such as field hospitals and other life saving priorities.
- All water-side communities should look into the use of boats for fire suppression and should plan for this contingency where other sources of water for fire suppression may not be available following an earthquake.

Health and Medical Care

Health and medical care refers to the normal services—including elective procedures—provided by Washington's hospitals, medical clinics, and other health care facilities. (Emergency care, which will be initiated immediately following an earthquake, is addressed above as part of the emergency response component.)

Target timeframe for response and recovery: 1 week–1month

Anticipated timeframe based on current capacity: 3 months–1 year

The actual response and recovery time will depend on a number of factors. For example:

- A number of hospitals and medical facilities may be damaged by the earthquake or secondary effects. The extent of the damage will in turn depend on factors such as the location of the facility, the seismic standards to which the facility was designed, and (in the case of older structures) whether the facility has been retrofitted.
- It will take time to restore the utilities—particularly water, wastewater, and electricity—on which medical facilities depend.
- The greater the number of people injured as a result of the earthquake, the greater will be the demand for staffed beds at undamaged hospitals and alternate care facilities. Currently, hospitals function at capacity, with few staffed beds available.)
- Patients at damaged hospitals may have to be evacuated and relocated to facilities in other cities and states.
- The extent to which the supply chain of hospitals and medical facilities is disrupted will vary, as will the amount of time it takes to re-establish sources and modes of delivery.

As a temporary aid to recovery, federally provided temporary medical facilities and assets can be brought into damaged areas to provide essential services while regular facilities are repaired or rebuilt.

This component can be said to have recovered when regular services have been restored and medical buildings are reoccupied up to 80 percent of the state's pre-disaster capacity (although some temporary solutions may still be in place in particular areas).

RECOMMENDATIONS

- Retrofit the existing buildings of hospitals and medical facilities so that they are able not only to withstand an earthquake, but to remain in use afterwards. Construct new buildings to meet this standard.
- Require hospitals to implement non-structural retrofits where this has not already been done.
- Retrofit and upgrade the parts of the utilities infrastructure on which hospitals depend to meet an operational level of performance, or require redundant systems to be in place for as long as needed until utility infrastructure is operational.
- Because hospitals and medical facilities rely on just-in-time delivery of pharmaceuticals and other supplies, their supply chains should be evaluated and upgraded to remain operational following an earthquake; alternatively, redundant supply chains should be established.
- Continue to push for improved credentialing (for example, quickly credential doctors to work in Washington).

Education

Education in this context refers to Washington's public and private school systems (kindergarten through grade 12).

Target timeframe for response and recovery: 1 week–1month
Anticipated timeframe based on current capacity: 3 months–1 year

The actual response and recovery time will depend on a number of factors. For example:

- A number of school buildings may be damaged by the earthquake or secondary effects. The extent of the damage will in turn depend on factors such as the location of the buildings, the seismic standards to which the buildings were designed, and (in the case of older structures) whether the buildings have been retrofitted.

- Many school buildings will serve as designated shelters following the earthquake. How long it takes to restore them to their original purpose will depend on how long they are needed as shelters.
- The feasibility of transporting students to alternate facilities or neighboring schools will depend on factors such as the state of the transportation system and the availability of buses and fuel.

To better define the recovery period of education, this component can be divided into three subcomponents:

- **The physical facilities.** Some school buildings are older than others and not all have been retrofitted to minimize earthquake damage. Those that sustain damage will have to be repaired or, in some cases, entirely rebuilt. The estimated timeframe for physical facilities is therefore *1–3 years*.
- **The curriculum.** Because alternate facilities can be used until buildings are repaired or replaced, the learning that takes place within the schools may be restored sooner than the school buildings themselves. To replace supplies, be able to track educational progress, develop alternative learning strategies, and restore the full curriculum and after-school activities is expected to take *3 months–1 year*.
- **The social aspects.** Schools serve a variety of social functions and provide many services to children, including mental health services and meals. Children also benefit mentally if their sense of normalcy is restored swiftly after a disaster: A regular school schedule helps provide this and allows parents to return to work. The restoration of these social aspects of education is possible within *1 month*.

RECOMMENDATIONS

- Extend the recently completed Washington State School Seismic Safety Pilot Project to the entire state to assess the seismic risk of school facilities across the state and determine which buildings are priorities for retrofitting and replacement. Complete retrofits or replacements of all vulnerable schools to achieve the desired performance objective.
- Further encourage school districts to develop pre-disaster mitigation plans through the state Emergency Management Division in order to qualify for FEMA funding (including structural and non-structural retrofits of school buildings).
- Examine the current process by which districts apply to OSPI for state funds for building and repair following a disaster and, to ensure a swift recovery, develop a mechanism for speeding up this process.
- Encourage schools and districts to explore alternative strategies for providing social and educational components of education. Encourage schools and districts to begin

formalizing a suite of alternative education strategies, such as facility-sharing, for a post-disaster environment.

Mass Care

Mass care is part of the emergency response following a disaster and involves the distribution of emergency supplies and resources (clothing, shelter, food, and water) to those in need. Some providers of mass care also seek to reconnect people to whatever social services they used before the disaster. Providers may include both nonprofit organizations, such as the Red Cross, and governmental agencies.

Target timeframe for response and recovery: 3–7 days for a major Cascadia subduction zone event with widespread damage; 1–3 days for a more localized event

Anticipated timeframe based on current capacity: 1 week–1 month

The actual response and recovery time will depend on a number of factors, including:

- The extent of the damage and the size of the area into which supplies and mobile facilities must be brought.
- The state of the transportation infrastructure and the availability of alternate routes in highly damaged areas.
- The impact of the earthquake on the housing stock and the number of people who must evacuate damaged homes and live in temporary shelters.

RECOMMENDATIONS

- Educate the public to prepare to be self-sufficient for at least three days following a disaster. Such preparations should include stocking a supply of food, water, and essential medications. Those who live in areas that are likely to be heavily impacted by a Cascadia subduction zone event or an earthquake on the Seattle fault should be encouraged to prepare supplies for a minimum of seven days.
- Future construction should be designed for usability, rather than just life-safety. Usability means that the structure can be used (inhabited) after an earthquake. This will allow a majority of the population to shelter-in-place and be self-sufficient for several days following the earthquake. In addition to facilitating a quicker recovery, this investment in the housing stock will serve the economic interests of the community and the state by reducing the likelihood that people will move elsewhere after the event.

Social Services

In Washington, the Department of Social and Health Services (DSHS) oversees the state's social services, including regular assistance with food, mental and physical health care, childcare, and treatment for addictions, as well as help for victims of physical abuse. Due to budget cuts, the people of Washington must rely increasingly on non-profit aid organizations for delivery of such services. A large-scale earthquake is likely to result in substantial temporary degradation of the level of service.

Target timeframe for response and recovery: 1 week–1month

Anticipated timeframe based on current capacity: 1 month–3 months

The actual response and recovery time will depend on a number of factors, including:

- The seismic vulnerability of buildings that house DSHS and social service providers and the extent to which these buildings are damaged by the earthquake or secondary effects.
- Whether social service providers have well developed continuity of operations plans.
- The ability of DSHS and social service providers to mobilize staff and access essential communications and information technologies (IT).

RECOMMENDATIONS

- Identify, review, and update the emergency response and continuity of operations plans of DSHS and all non-profit social service providers. These plans should take into account the network on which the providers depend and should be reassessed annually.
- DSHS provides a "2-1-1" referral service (accessible by phone), which promotes some planning with partner organizations. Planning with partner organizations on a regional basis should be promoted. Regional networks that include the smaller jurisdictions should also be further developed.
- Develop a database that helps emergency responders identify and locate non-profit social service providers.

Food Network

Food network refers to the normal system by which food is stored, distributed, and sold to consumers. This network is operated by the private sector and includes nationally, regionally, and locally owned grocery stores as well as warehouses.

Target timeframe for response and recovery: 1 week–1 month

Anticipated timeframe based on current capacity: 1 week–1 month

The actual response and recovery time will depend on a number of factors, including:

- The state of the transportation infrastructure (roads, bridges, rail lines, ferries, ports, and airports) by means of which the network distributes food, and the length of time it takes to make repairs or identify efficient alternate routes.
- The length of time it takes to restore essential utilities (electricity and water) to grocery stores and warehouses.
- The extent of structural and nonstructural damage to stores and warehouses.

The recovery of the food network is defined by its ability to deliver a relatively normal food supply at costs that are also close to normal. Because the state of Alaska is dependent on Washington for its food supply, the recovery of Washington's food network will also be of great concern to Alaska and will have economic consequences for both states.

Two of the food network's chief vulnerabilities are its dependence on the transportation system and the location of its distribution centers. Most of the latter are in the Kent Valley in King County. This valley is prone to liquefaction, so warehouses there may sustain significant damage during an earthquake. The estimates in the table assume a relatively swift recovery of the transportation system, allowing food, workers, and consumers to reach stores.

National grocery chains, by virtue of their size, may be better positioned to recover from a damaging earthquake than many local and regional businesses.

RECOMMENDATIONS

- Educate the public to prepare to be self-sufficient for at least three days following a disaster. Such preparations should include stocking a supply of food, water, and essential medications. Those who live in areas that are likely to be heavily impacted by a Cascadia subduction zone event or an earthquake on the Seattle fault should be encouraged to prepare supplies for a minimum of seven days.
- Gather additional input from the owners and managers of grocery stores and food distribution centers regarding the levels of redundancy in their supply chain systems.
- Where sufficient redundancy does not exist, require that food distribution systems be designed or upgraded to higher standards to achieve performance objectives.
- Best practices in food supply chain management from recent incidents in Japan, Chile, and New Zealand should be incorporated into local, state, and federal response plans.

Government Administration

Government administration refers to elected officials and staff at the local and state levels and includes both emergency operations and regular administrative functions. This component has multiple parts or aspects, including representation, finance, policy development, executive decision making, and services (such as the issuing of licenses and permits).

Target timeframe for response and recovery: 3–7 days
Anticipated timeframe based on current capacity: 1 week–1 month

The actual response and recovery time will depend on a number of factors. For example:

- The extent of damage to the facilities that house the operations of government will depend on factors such as the location of the buildings, the seismic standards to which the buildings were designed, and (in the case of older structures) whether the buildings have been retrofitted. The length of time it takes to repair or replace damaged buildings will vary accordingly.
- The response and recovery will be quicker if back-up facilities already exist and are undamaged.
- Temporary facilities must be found to house key personnel and functions while repairs are being made.
- Effective response and recovery both depend on the performance of communications systems, including both the cell network and emergency backup systems (satellite phones and ham radios).
- The effectiveness of each agency's emergency plan influences the overall recovery of this component. Likewise, the development prior to an earthquake of a Continuity of Government (COG) Plan, including the ability to locate elected officials after the event, will facilitate a quicker response and recovery.

Particular aspects of government, notably decision making, finance, and information technology (IT), are generally expected to be restored within 3–7 days. Many of these functions can be carried out in temporary facilities and can be restored before physical structures are repaired. It is particularly important that financial functions be restored in less than a week. Building and planning departments should also be functioning within a week of the event, provided staff can access the facility. Other non-essential functions of government can take up to a month to recover without detrimentally affecting the state's resilience.

While some functions, such as decision making, can easily be carried out in temporary facilities, others, such as the issuing of permits and licenses, are more dependent on particular facilities,

information systems, and equipment. If these are seriously damaged, then the current recovery timeframe may be as long as 3 months–1 year.

The state government in Olympia has backup facilities in Spokane. Most local governments, however, are unlikely to have robust backups, generally because their backups tend to be located within the same general region. In a significant earthquake, the backup facilities may experience as much damage as the primary facilities.

RECOMMENDATIONS

- Government administrators of all jurisdictions should identify which facets of their operations are critical and should have plans to provide continuity of service for these areas. Continuity of Operations (COOP) plans should identify areas that are unlikely to be in the main impact zones of an earthquake (or tsunami).
- Identify, review, and update annually the continuity of operations plans of all jurisdictions (both large and small) to ensure that these plans are robust and that personnel are trained to implement them.
- At all three levels of government (local, state, and federal), encourage a stronger emphasis on recovery planning in addition to response.

General Recommendations

- Further investigate and define the risk associated with loss of power, water, and wastewater to critical service providers. Our anticipated timeframes for recovery have assumed that widespread outages of these utilities will not extend beyond a few days, while much more localized loss could happen for longer time periods.
- As part of pre-disaster planning, consider the impacts of the potential loss of utilities at critical facilities (e.g. hospitals) and develop strategies to provide redundant systems locally.
- Given the tsunami hazard along Washington's coast, new public (critical services) structures that are built in the inundation zone should be designed to serve as vertical evacuation shelters. To facilitate this, the new Appendix M of the 2012 International Building Code (IBC) should be adopted at the state level. This would restrict construction of high occupancy, high risk, or critical facilities within the tsunami inundation zone unless these structures are designed and built as vertical evacuation refuges.
- Require those who are engaging in response and recovery planning to take into account where their critical service providers live relative to where they serve, as well as how concerns about the safety of their family members may affect the availability of critical service providers.

Utilities Sector

The following table provides a summary of the estimated timeframes for recovery of key components of the infrastructure, systems, and services of the Utilities sector in the state of Washington. The letters (***L***, ***NL***, and ***X***) indicate the sector group's best educated guess regarding the current timeframe for the response and recovery of each component and subcomponent after a scenario earthquake. The colored areas represent the goals or targets for each component and subcomponent. (These targets indicate the recovery timeframes that are necessary to achieve resilience in the state of Washington.) The gaps between the letters and the colored areas reveal the need for further evaluation, policies, and actions to improve Washington's resilience.

The estimates proposed in the table reflect the recovery potential of the existing, permanent utilities systems. Because of the variable nature of earthquake damage and the way these systems function, restoration of service will depend on the end user's geographical location.

Although temporary solutions can be implemented in some cases, restoring service to end-users depends on restoration of the system as a whole and so will not occur incrementally. Also, the estimates do not include the time involved in restoring the final points of connection between the utilities systems and individual houses and facilities.

KEY TO THE TABLE

TARGET TIMEFRAME FOR RECOVERY:	
Operational (time it ought to take to restore component to 80-90% operational):	
TIME NEEDED FOR RECOVERY TO 80-90% OPERATIONAL GIVEN CURRENT CONDITIONS:	✕
TIME NEEDED FOR RECOVERY TO 80-90% OPERATIONAL IN LIQUEFACTION ZONES GIVEN CURRENT CONDITIONS:	***L***
TIME NEEDED FOR RECOVERY TO 80-90% OPERATIONAL IN NON-LIQUEFACTION ZONES GIVEN CURRENT CONDITIONS:	***NL***

TARGET STATES OF RECOVERY: WASHINGTON'S UTILITIES SECTOR

	Event occurs	0–24 hours	1–3 days	3–7 days	1 week–1 month	1 month–3 months	3 months–1 year	1 year–3 years	3 + years
Domestic water supply									
Supply & transmission pipes				***NL***			***L***		

Distribution pipes					NL		L		
Wastewater systems									
Treatment facilities						NL	L		
Sewer pipes						NL		L	
Flood control									
Dams						×			
Levees								×	
Electricity									
Transmission								×	
Distribution, 60% restored					×				
Distribution, 70% restored						×			
Distribution, greater than 70% restored							×		
Natural Gas									
Transmission			NL		L				
Distribution, 40% restored					×				
Distribution, 90% restored						×			
Petroleum									
Refineries & transmission								×	
Distribution						×			
Information and communication technology						×			
	Event occurs	0–24 hours	1–3 days	3–7 days	1 week–1 month	1 month–3 months	3 months–1 year	1 year–3 years	3 + years

Domestic Water Supply

This component consists of reservoirs, storage facilities, treatment facilities, pump stations, transmission pipelines, and distribution pipelines for household, business, and emergency services use. It does not include pipelines and hookups on customers' private property: these must be repaired by the property owner. Nevertheless, private residences and facilities will likely require inspection before service can be restored.

Target timeframe for response and recovery:

- *Supply & transmission pipes: 1–3 days*
- *Distribution pipes: 1–3 days*

Anticipated timeframe based on current capacity:

- *Supply & transmission pipes: 3–7 days in zones of no liquefaction; 3 months–1 year in liquefaction zones*
- *Distribution pipes: 1 week–1month in zones of no liquefaction; 3 months–1 year in liquefaction zones*

The actual restoration and recovery times of domestic water service will depend on a number of factors. For example:

- Damage will be more severe and require more extensive repair if the fault rupture is coincident with a pipeline, such as the Cedar River pipelines and the Eastside supply line in Bellevue.
- A significant amount of time will be needed to repair components located in liquefaction zones (such as the Kent Valley) or areas subject to other ground failure unless these components are pile-supported.
- Factors such as fault proximity, topography, and soil type are likely to increase the level of ground motion and the time required to repair the system's damaged components.
- The extent of damage and the time required to repair above-ground structures will be reduced if the structures have been appropriately designed. Older structures that have not been upgraded are likely to suffer greater damage.
- Equipment (such as backup power systems) inside pump stations and control centers is more likely to be damaged if it is not properly anchored. This will increase the time needed to restore service.
- Damage to major transmission lines or to large (20" and larger) distribution mains will likely result in de-watering of large portions of the water system. This could include the draining of reservoirs, tanks, and standpipes. De-watering will increase the time required to make repairs.
- If a system is in a tsunami zone, wells are likely to be contaminated and components of the system may be undermined by erosion.
- Systems that have redundant supplies—such as the City of Seattle's system—are likely to experience either shorter periods without service or no loss of service.
- If customers' hookups are damaged, service cannot be restored until the hookups are repaired. Turning the service back on at the hookup will likely require inspection by trained personnel, of whom there is a limited number.
- Initial response by water utilities companies to earthquake damage will focus on isolating main leaks and breaks in order to prevent further damage or disruption of water service to other areas. The time required for repairs will depend on the number of leaks and breaks, as well as the speed with which leaks and breaks can be accessed and identified.

- The time required to restore service to a particular area will be affected by decisions about the priorities and schedule for restoration of one affected area over another. For example, the flow of water for fire suppression can only be restored after repairs are made and water service resumed in the particular area.
- Water supply lines must be disinfected prior to restoration of full service. This will increase the restoration time.
- Temporary measures can be taken to restore service quickly while permanent repairs are being made. These measures include temporarily bypassing damaged pipe sections or using temporary water supplies, such as trucked or bottled water.
- The speed with which repairs are made is limited by the availability of repair crews. Such personnel often require credentials, so their numbers cannot be quickly augmented after an earthquake.
- Repair crews, including private contractors, must be able to use roads and bridges. Debris will have to be cleared before they can access damaged facilities. Repairs will be delayed if crews are not given access at the same time as emergency response vehicles. Because private contractors may not be easy to identify as contractors of the utility company, they may not be granted access.
- Mutual aid for augmenting repair crews is unlikely to be available in a large Cascadia subduction zone event because of the expected widespread damage.
- The availability for delivery of the parts and equipment needed to repair and replace damaged sections of the system will affect the time required to make repairs. Most utilities do not maintain large inventories of pipes, fittings, and other parts.
- The time period within which temporary service measures and repairs can be made will depend on the status of communications systems and whether there are functional backup communication systems.
- On-site backup power will likely be needed at control centers, treatment plants, and pump stations to ensure that these facilities continue to function. Some pump stations do not have generators and instead are connected to two different electrical substations for redundancy. Pump stations are not required for gravity-fed systems.
- Depending on the amount of fuel located at the facility and whether additional fuel can be delivered, the facility may lose backup power before the primary power is restored.
- If on-site backup power is not available, mobile generators may be delivered. This will require access to roadways and bridges. The lack of external "quick" hookups for connecting mobile generators may increase the service restoration time.
- The target timeframe for the restoration of water service is necessary primarily for fire suppression.

In general, systems and facilities that are located in and on competent soils, such as on the plateaus around Everett, Seattle, and Tacoma, are likely to sustain less damage during an earthquake and may be restored within a matter of days. Systems located in areas where soils are prone to liquefaction are likely to experience significant damage and will therefore take longer to restore. Only the most vulnerable structures will be damaged in the foothills of the Cascades. For the most part in Puget Sound, the domestic water supply is gravity fed and does not need electricity to flow.

RECOMMENDATIONS

- Require that utilities have backup generators at treatment plants as well as at pump stations. Do not allow the use of the connection of stations to two different electrical substations to satisfy the requirement.
- Regulate anchorage of equipment.
- Require all water utilities to assess the earthquake risk of their systems, including expected outage time, damage due to fire following the earthquake, and economic damage to the utility and the community. Develop a plan to improve the system to meet the desired level of service, estimate the cost of improvement, and assess the cost of the improvements compared to expected losses. This should be done as part of the water system comprehensive planning process and updated on a regular basis.
- Require all new pipelines to be designed to be operational following the design earthquake.
- Replace all highly vulnerable water mains that are located in liquefiable and other unstable soils. Replace them with pipeline systems that are resistant to permanent ground deformation.
- See general recommendations.

Wastewater Systems

This component consists of sewer and stormwater systems, including wastewater pump stations, transmission and distribution pipelines, catch basins, and wastewater treatment facilities. It does not include pipelines and hookups on customers' private property: these must be repaired by the property owner. Nevertheless, private residences and facilities will likely require inspection before service can be restored.

Target timeframe for response and recovery:

- *Treatment facilities: 1 week–1 month*
- *Sewer pipes: 1 week–1month*

Anticipated timeframe based on current capacity:

- *Treatment facilities: 1month–3 months in zones of no liquefaction; 3 months–1 year in liquefaction zones*
- *Sewer pipes: 1 month–3 months in zones of no liquefaction; 1 year–3 years in liquefaction zones*

The actual restoration and recovery times of wastewater services will depend on a number of factors. For example:

- Damage will be more severe and require more extensive repair if the fault rupture is coincident with a pipeline.
- A significant amount of time will be needed to repair components located in liquefaction zones (such as the Kent Valley) or areas subject to other ground failure. Any settlement of sewage pipes will prevent flow in gravity flow systems. Pile-supported facilities are less likely to suffer significant damage.
- Factors such as fault proximity, topography, and soil type are likely to increase the level of ground motion and the time required to repair damaged components.
- The extent of damage and time required to repair above-ground structures will be reduced if the structures have been appropriately designed. Older structures that have not been upgraded are likely to suffer greater damage.
- The equipment (such as backup power systems) inside pump stations and control centers is more likely to be damaged if it is not properly anchored. This will increase the time needed to restore service.
- The time required to make repairs will depend on the number of leaks and breaks, as well as the speed with which leaks and breaks can be accessed and identified.
- The extent to which debris from the earthquake blocks inlets, catch basins, and pipes of the stormwater system will influence service restoration.
- Heavy rainstorms during the recovery period will complicate repair efforts by overloading drainage and wastewater systems.
- If customers' hookups are damaged, service cannot be restored until the hookups are repaired. Turning the service back on at the hookup will likely require inspection by trained personnel, of whom there is a limited number.
- The time required to restore service to a particular area will be affected by decisions about the priorities and schedule for restoration of one affected area over another.
- Temporary measures can be taken to restore service quickly while permanent repairs are being made. These measures include temporarily bypassing damaged sections of pipes.

- The speed with which repairs are made is limited by the availability of repair crews. Such personnel often require credentials, so their numbers cannot be quickly augmented after an earthquake.
- Repair crews, including private contractors, must be able to use roads and bridges. Debris will have to be cleared before they can access damaged facilities. Repairs will be delayed if crews are not given access at the same time as emergency response vehicles. Because private contractors may not be easy to identify as contractors of the utility company, they may not be granted access.
- Mutual aid for augmenting repair crews is unlikely to be available in a large Cascadia subduction zone event because of the expected widespread damage.
- The availability for delivery of parts and equipment needed to repair and replace damaged sections of the system will affect the time required to make repairs. Most utilities do not maintain large inventories of pipes, fittings, and other parts.
- The time period within which temporary service measures and repairs can be made will depend on the status of communications systems and whether there are functional backup communication systems.
- On-site backup power will likely be needed at control centers, treatment plants, and pump and lift stations to ensure that these facilities continue to function. Some pump stations do not have generators and instead are connected to two different electrical substations for redundancy. This meets EPA requirements, but will not provide power in the instance of widespread power outage. Pump stations are not required for gravity-fed systems.
- Depending on the amount of fuel located at the facility and whether additional fuel can be delivered, the facility may lose backup power before the primary power is restored.
- If on-site backup power is not available, mobile generators may be delivered. This will require access to roadways and bridges. The lack of external "quick" hookups for connecting mobile generators may increase service restoration time.

In general, systems and facilities that are located in and on competent soils, such as on plateaus, are likely to sustain less damage during an earthquake. Those that have been appropriately designed or seismically upgraded may be restored within a week. Systems located in areas where soils are prone to liquefaction are likely to experience significant damage and will therefore take longer to restore. For example, most of the wastewater treatment facilities that serve communities along the I-5 corridor—such as Everett, Seattle, and Tacoma—are located on liquefiable soils. Liquefaction will cause sewers and non-pile supported pump stations to float or be displaced. Full restoration of these systems and facilities could take as long as two years.

RECOMMENDATIONS

- Quantify how much of the wastewater system will not be functioning for 1–3 years following an earthquake. Compare the results and expected effects with the recent experience of Japan following the M9.0 earthquake near the east coast of Honshu.
- Discuss with decision makers and the public the issues related to discharging sewage into rivers after an earthquake.
- Require that utilities have backup generators at treatment plants as well as at pump and lift stations. Do not allow the use of the connection of stations to two different electrical substations to satisfy this requirement.
- Regulate anchorage of equipment.
- Require all wastewater utilities to assess the earthquake risk of their systems, including expected outage time and public health, environmental impacts, and economic damage to the utility and the community. Develop a plan to improve the system to meet the desired level of service, estimate the costs of improvement, and assess the cost of the improvements compared to expected losses. This should be done as part of the water system comprehensive planning process and updated on a regular basis.
- Require all new and retrofitted wastewater facilities, including pipelines, and all existing sewers 24-inches in diameter or greater, to be functional following the design earthquake.

Flood Control

This component consists of the dams, levees (including both manmade and natural river banks), and other structures that reduce the likelihood of impacts from flooding.

Target timeframe for response and recovery:

- *Dams: 1 week–1 month*
- *Levees: 1 week–1 month*

Anticipated timeframe based on current capacity:

- *Dams: 1 month–3 months*
- *Levees: 1 year–3 years*

The actual restoration and recovery time will depend on a number of factors. For example:

- The time needed to make repairs depends on the total length of the damaged levees.
- Damage to flood control depends on the particular level of ground shaking at a location, which is influenced by factors such as fault proximity, topography, and soil type.

- Levees that are located in liquefiable soils are susceptible to greater damage and will take longer to repair. Landslides and settlement will also affect repair times.
- Repair times are influenced by the availability of repair crews and whether the transportation system has been sufficiently restored to allow crews to access damaged structures.
- Access to and time required to repair levees depends on whether they are located on public or private property.
- Some levees will need to be accredited for the National Flood Insurance Program.

Because Washington's dams were built to a high seismic design standard,[1] they are expected to perform well in earthquakes as severe as the Seattle fault scenario and the Cascadia subduction zone scenario.

The state's extensive levee system, on the other hand, may be extensively damaged. Less than two percent of Washington's levees were designed to the seismic standards of the Corp of Army Engineers,[2] and even this standard is not sufficient to address the intensity of ground shaking anticipated in the Seattle fault or Cascadia subduction zone scenarios.

RECOMMENDATIONS

- Assess the state levee system's risk with respect to ground motion and liquefaction. This can be done using information from the USGS, Department of Natural Resources, and Department of Ecology.
- Require that seismic design standards be met in some areas to receive National Flood Insurance accreditation.
- See general recommendations.

Electricity

This component consists of generation facilities, substations, transmission towers, transmission lines and equipment, distribution poles and equipment, and control centers. It does not include hookups on customers' private property: these must be repaired by the property owner. Nevertheless, private residences and facilities will likely require inspection before service can be restored.

Target timeframe for response and recovery: 1 week–1 month

Anticipated timeframe based on current capacity:

[1] The criteria are based on an earthquake event that typically has a 2% chance of exceedance in 50 years (that is, an event that has a 2,475-year return period).
[2] The Corp of Army Engineers' criteria are based on a design earthquake event that has a return period of 100 years.

- *Transmission: 1year–3 years*
- *Distribution: 60% restored in 1 week–1 month; 70% restored in 1 month–3 months; greater than 70% restored in 3 months–1year*

The actual response and recovery time will depend on a number of factors. For example:

- Factors such as fault proximity, topography, and soil type are likely to increase the level of ground motion and the time required to repair damaged components.
- Repairs will depend on the extent of damage to transmission towers, substations, and lines as a result of earthquake-induced ground failures (e.g. landslides).
- Because high voltage transmission substations are more vulnerable than low voltage distribution substations, they are likely to suffer more damage and require extensive repairs.
- The number of substations that are damaged affects the redundancy of the system and the company's ability to reroute electricity in order to maintain service.
- If power generation or transmission went out of service before distribution, the number and geographic extent of needed repairs is likely to be larger and will require more time to repair.
- The extent of damage and the time required to repair above-ground structures will be reduced if the structures have been appropriately designed. Older structures that have not been upgraded are likely to suffer greater damage.
- The equipment (such as racks of capacitors and batteries) inside power plants, substations, and control centers is more likely to be damaged if it is not properly anchored. This will increase the time needed to restore service.
- If customers' hookups are damaged, service cannot be restored until the hookups are repaired. Turning the service back on at the hookup will likely require inspection by trained personnel, of whom there is a limited number.
- The time required to restore service to a particular area will be affected by decisions about the priorities and schedule for restoration of one affected area over another.
- Temporary measures can be taken to restore service quickly while permanent repairs are being made. For example, damaged monitoring or safety equipment, such as lightning arrestors or circuit breakers, can be bypassed.
- The speed with which repairs are made is limited by the availability of repair crews. Such personnel often require credentials, so their numbers cannot be quickly augmented after an earthquake.
- Repair crews, including private contractors, must be able to use roads and bridges. Debris will have to be cleared before they can access damaged facilities. Repairs will be delayed

if crews are not given access at the same time as emergency response vehicles. Because private contractors may not be easy to identify as contractors of the utility company, they may not be granted access.

- Mutual aid for augmenting repair crews is unlikely to be available in a large Cascadia subduction zone event because of the expected widespread damage.
- The availability for delivery of the parts and equipment needed to repair and replace damaged sections of the system will affect the time required to make repairs. Most utilities do not maintain large inventories of pipes, fittings, and other parts. High voltage transformers are extremely expensive, take a long time to manufacture, and are difficult to transport.
- The time period within which temporary service measures and repairs can be made will depend on the status of communications systems and whether there are functional backup communication systems.
- The post disaster demand for electricity and whether the utilities companies can communicate with major customers to reduce large loads influences their ability to turn circuits back on.
- Winter weather and cold temperatures could lengthen the recovery timeframe.

High voltage (500 kV and 230 kV) transmission substations tend to be the most vulnerable parts of the system, and it could take months to replace damaged transformers, which are designed for specific substations and manufactured in Asia. Replacement of damaged substations depends heavily on the state of the transportation system: Substations must be transported along routes that are equipped or reinforced to take a substation's size and weight. Historically, transmission tower failures have occurred only as a result of ground failures. Areas affected by landslides could experience a lengthier recovery timeframe.

On the whole, power transmission systems are considered to be robust, and there is enough redundancy in the electrical grid to allow service to continue even if several substations are damaged. Also, in the event of an earthquake, additional utilities repair personnel can be brought in to assist the regular repair crews.

The estimates in the table reflect the time needed to restore the electrical grid/system. Damage to residences, industrial facilities, and commercial buildings must also be repaired, inspected, and approved before these structures can be reconnected to the grid. In some cases, this could take longer than six months.

For many people, however, service will be restored before the wider system is fully repaired. To facilitate the broader restoration of the system, customers with electrical power may have to curtail their use of electricity or put up with rolling blackouts. Temporary solutions, such as

mobile power plants provided by the Army Corps of Engineers or the use of backup power provided by nuclear submarines or carriers, may be implemented in some locations.

RECOMMENDATIONS

- Create a national or regional standard for replacement parts (such as transformers) for electrical systems. Alternatively, consider in advance how systems will or can be modified to make use of parts from other power companies.
- Regulate anchorage of equipment.
- Analyze the benefit of decentralized power generation and smart-grid technology on seismic resilience.
- See general recommendations.

Natural Gas

This component includes natural gas transmission pipelines and facilities, as well as the owners and operators of the pipelines. It does not include pipelines and hookups on customers' private property: these must be repaired by the property owner. Nevertheless, private residences and facilities will likely require inspection before service can be restored.

Target timeframe for response and recovery:

- *Transmission: 1–3 days*
- *Distribution: 1 week–1 month*

Anticipated timeframe based on current capacity:

- *Transmission: 1–3 days in zones of no liquefaction; 1 week–1 month in liquefaction zones*
- *Distribution: 40% restored in 1 week–1 month; 90% restored in 1 month–3 months*

The actual response and recovery time will depend on a number of factors. For example:

- Damage will be more severe and require more extensive repair if the fault rupture is coincident with a pipeline.
- A significant amount of time will be needed to repair components located in liquefaction zones (such as Harbor Island in Seattle) or areas subject to other ground failure. Any settlement of pipes will prevent flow in gravity flow systems. Pile-supported facilities are less likely to suffer significant damage.
- Factors such as fault proximity, topography, and soil type are likely to increase the level of ground motion and the time required to repair damaged components.

- The extent of damage and time required to repair above-ground structures will be reduced if the structures have been appropriately designed. Older structures that have not been upgraded are likely to suffer greater damage.
- The equipment (such as backup power systems) inside control centers is more likely to be damaged if it is not properly anchored. This will increase the time needed to restore service.
- The time required to make repairs will depend on the number of leaks and breaks, as well as the speed with which leaks and breaks can be accessed and identified.
- Flooded pipes will have to be cleaned; this will lengthen the restoration time.
- If customers' hookups are damaged, service cannot be restored until the hookups are repaired. Turning the service back on at the hookup will likely require inspection by trained personnel, of whom there is a limited number.
- The time required to restore service to a particular area will be affected by decisions about the priorities and schedule for restoration of one affected area over another.
- Temporary measures can be taken to restore service quickly while permanent repairs are being made. These measures include temporarily bypassing damaged sections of pipes.
- The speed with which repairs are made is limited by the availability of repair crews. Such personnel often require credentials, so their numbers cannot be quickly augmented after an earthquake.
- Repair crews, including private contractors, must be able to use roads and bridges. Debris will have to be cleared before they can access damaged facilities. Repairs will be delayed if crews are not given access at the same time as emergency response vehicles. Because private contractors may not be easy to identify as contractors of the utility company, they may not be granted access.
- Mutual aid for augmenting repair crews is unlikely to be available in a large Cascadia subduction zone event because of the expected widespread damage.
- The availability for delivery of parts and equipment needed to repair and replace damaged sections of the system will affect the time required to make repairs. Most utilities do not maintain large inventories of pipes, fittings, and other parts.
- The time period within which temporary service measures and repairs can be made will depend on the status of communications systems and whether there are functional backup communication systems.
- On-site backup power will likely be needed at control centers, compressor stations, and regulator stations to ensure that these facilities continue to function.
- Depending on the amount of fuel located at the facility and whether additional fuel can be delivered, the facility may lose backup power before the primary power is restored.

- If on-site backup power is not available, mobile generators may be delivered. This will require access to roadways and bridges. The lack of external "quick" hookups for connecting mobile generators may increase service restoration time.
- Repair crews and qualified personnel must be available to relight customers' appliances. Such personnel often require credentials, so their numbers cannot be quickly augmented after an earthquake.
- A number of customers will turn off their gas or have an earthquake actuated shutoff valve. In past earthquakes, the majority of customers who turned off their gas did so needlessly. Unnecessary shutoffs increase the work load and thus the time required for natural gas employees or qualified professionals to relight customers' appliances.

Pipeline damage is most likely to occur as a result of liquefaction and landslides on steep slopes. While very strong ground shaking can damage pipelines, it is more likely to damage the above-ground facilities. Based on past experience of earthquakes in the western United States, modern, buried, arc-welded pipelines made of high-carbine steel are expected to perform well. Pipeline operators have replacement pipes on hand and are normally able to repair breaks in a matter of days.

The Washington Utilities and Transportation Commission's Pipeline Safety Section and the Washington State Department of Ecology must approve repair plans and operations. Once repaired, the pipeline may have to operate at reduced pressure for a while, and inspections of the pipeline may continue for several months to confirm its integrity.

In addition, homes must be inspected and approved before the gas can be hooked up to them again. The time needed to accomplish such inspections will depend on the number of qualified inspectors available, and the estimates provided in the table do not include this final step.

RECOMMENDATIONS

- Require on-site backup power for critical components of the system.
- Regulate anchorage of equipment.
- See general recommendations.

Petroleum

This component includes petroleum (gasoline, diesel, jet fuel, and crude oil) transmission pipelines, terminals, and refineries, as well as their owners and operators. It does not include pipelines and hookups on customers' private property: these must be repaired by the owners of the property.

Target timeframe for response and recovery:

- *Refineries and transmission: 1 week–1 month*
- *Distribution: 3–7 days*

Anticipated timeframe based on current capacity:

- *Refineries and transmission: 1 year–3 years*
- *Distribution: 1 month–3 months*

The actual response and recovery time will depend on a number of factors. For example:

- Damage will be more severe and require more extensive repair if the fault rupture is coincident with a pipeline.
- A significant amount of time will be needed to repair components located in liquefaction zones (such as Harbor Island in Seattle) or areas subject to other ground failure. Any settlement of pipes will prevent flow in gravity flow systems. Pile-supported facilities are less likely to suffer significant damage.
- Factors such as fault proximity, topography, and soil type are likely to increase the level of ground motion and the time required to repair damaged components.
- The extent of damage and the time required to repair above-ground structures will be reduced if the structures have been appropriately designed. Older structures that have not been upgraded are likely to suffer greater damage.
- The equipment (such as backup power systems) inside control centers is more likely to be damaged if it is not properly anchored. This will increase the time needed to restore service.
- The time required to make repairs will depend on the number of leaks and breaks, as well as the speed with which leaks and breaks can be accessed and identified.
- If customers' hookups are damaged, service cannot be restored until the hookups are repaired. Turning the service back on at the hookup will likely require inspection by trained personnel, of whom there is a limited number.
- The speed with which repairs are made is limited by the availability of repair crews. Such personnel often require credentials, so their numbers cannot be quickly augmented after an earthquake.
- Repair crews, including private contractors, must be able to use roads and bridges. Debris will have to be cleared before they can access damaged facilities. Repairs will be delayed if crews are not given access at the same time as emergency response vehicles. Because private contractors may not be easy to identify as contractors of the utility company, they may not be granted access.
- Mutual aid for augmenting repair crews is unlikely to be available in a large Cascadia subduction zone event because of the expected widespread damage.

- The availability for delivery of the parts and equipment needed to repair and replace damaged sections of the system will affect the time required to make repairs. Most utilities do not maintain large inventories of pipes, fittings, and other parts.
- The time period within which temporary service measures and repairs can be made will depend on the status of communications systems and whether there are functional backup communication systems.
- On-site backup power will likely be needed at control centers, pump stations, and refineries to ensure that these facilities continue to function.
- Depending on the amount of fuel located at the facility and whether additional fuel can be delivered, the facility may lose backup power before the primary power is restored.
- If on-site backup power is not available, mobile generators may be delivered. This will require access to roadways and bridges. The lack of external "quick" hookups for connecting mobile generators may increase service restoration time.

Pipeline damage is most likely to occur as a result of liquefaction and landslides on steep slopes. While very strong ground shaking can damage pipelines, it is more likely to damage the above-ground facilities. Based on past experience of earthquakes in the western United States, modern, buried, arc-welded pipelines made of high-carbine steel are expected to perform well. Damaged refineries, however, could take a long time to fix.

The Washington Utilities and Transportation Commission's Pipeline Safety Section and the Washington State Department of Ecology must approve repair plans and operations. Once repaired, the pipeline may have to operate at reduced capacity for a considerable period of time, possibly years.

During the recovery period, consumers may have to use petroleum products that are refined elsewhere and brought in by truck or barge. The price of these supplies will be high, and there will be considerable competition for them.

RECOMMENDATIONS

- Require on-site backup power for critical components of the system.
- Regulate anchorage of equipment.
- See general recommendations.

Information and Communication Technology

This component consists of a wide range of communications systems and technologies, including hard-wired telephone and cable TV systems, wireless cellular phone systems, and 800 MHZ public service radio systems. Most communications services are provided by privately owned

and operated companies, although the 800 MHZ, which is used primarily by police, fire, and emergency medical response agencies, is publicly owned and controlled.

Target timeframe for response and recovery: 3–7 days
Anticipated timeframe based on current capacity: 1 month–3 months

The actual response and recovery time will depend on a number of factors. For example:

- Factors such as fault proximity, topography, and soil type are likely to increase the level of ground motion and the time required to repair the system's damaged components.
- The extent of damage and the time required to restore service depends on whether buildings that house key elements of systems, such as Internet hubs or land-line central offices, have been engineered or seismically retrofitted to withstand the level of ground shaking experienced.
- Equipment, such as uninterruptable power supplies, that is not properly anchored will likely be damaged. This will increase the time needed to restore service.
- If customers' hookups are damaged, service cannot be restored until these hookups are repaired.
- The time required to restore service to a particular area will be affected by decisions about the priorities and schedule for restoration of one affected area over another.
- The speed with which repairs are made is limited by the availability of repair crews. Such personnel often require credentials, so their numbers cannot be quickly augmented after an earthquake.
- Repair crews, including private contractors, must be able to use roads and bridges. Debris will have to be cleared before they can access damaged facilities. Repairs will be delayed if crews are not given access at the same time as emergency response vehicles. Because private contractors may not be easy to identify as contractors of the utility company, they may not be granted access.
- Mutual aid for augmenting repair crews is unlikely to be available in a large Cascadia subduction zone event because of the expected widespread damage.
- The time period within which repairs can be made will depend on the status of backup communications systems.
- The service restoration estimates in the table assume that the ICT systems are equipped with effective backup generators. The installation of such generators is common practice in the industry.

On the whole, the hard-wired systems are expected to perform well. For example, most installations have emergency power. Wireless communications systems may be less robust.

All of these systems (hard-wired, wireless, and 800MHZ) may be overloaded by users in the aftermath of an earthquake. This is of particular concern in the case of emergency responders, for whom communication with dispatchers and other responders is essential.

RECOMMENDATIONS

- Require on-site backup power for critical components of the system.
- Regulate anchorage of equipment.
- See general recommendations.

General Recommendations

- Plan for, invest in, and prioritize temporary strategies, such as generators, water, and fuel delivery.
- Plan for and prioritize debris management.
- Plan for, invest in, and prioritize repair-parts supply chains. Evaluate approval/inspection policies in light of post-disaster situations.
- Consider regulations/rules for prioritizing service restoration to critical facilities.
- Create a separate *Resilient Utilities* process to further investigate this sector.
- Create a permanent utilities committee of utility service providers that works on disaster planning and exercises.
- Review the state's rules and regulations and create an inventory of those that may pose challenges during the recovery phase. Create a process for developing potential alternative solutions that would better fit a recovery situation, making sure that the need to expedite permits is balanced with the need to ensure the quality and safety of repairs and the protection of the environment. (Such an examination should involve utilities managers and providers as well as government decision makers and regulators.) Communicate the results (the status of the various rules and regulations after an earthquake) to local jurisdictions and relevant industries.
- Develop a process that identifies the person, group, or agency with authority to decide who should have priority for emergency resources (such as backup generators and fuel).
- Develop some form of credentialing for repair crews in emergency situations.
- Mandate that infrastructure providers determine their risk and make such risk assessments available (in some form) to the state and other providers.
- Analyze incentives that can be offered by the state to utility providers to encourage them to invest in mitigation.

- Ensure that there is appropriate redundancy in communication systems.
- Do large scale mapping of liquefaction, landslide, and fault rupture hazards to identify possible damage locations of utility components.
- Consider separately the restoration of permanent service and the restoration of temporary service. Identify targets and capacity estimates for both, and offer recommendations for both the temporary solutions (such as backup generators) and the permanent restoration of service. Also, identify the interdependencies of the temporary solutions, which tend to be more complex than the interdependencies of permanent repairs.

Transportation Sector

The following table provides a summary of the estimated timeframes for recovery of key components of the infrastructure, systems, and services of the Transportation sector in the state of Washington. The Xs indicate the sector group's best educated guess regarding the current timeframe for the response and recovery of each component and subcomponent after a scenario earthquake. The colored areas represent the goals or targets for each component and subcomponent. (These targets indicate the recovery timeframes that are needed to achieve resilience in the state of Washington.) The gaps between the Xs and the colored areas reveal the need for further evaluation, policies, and actions to improve Washington's resilience.

KEY TO THE TABLE

TARGETS TO ACHIEVE DIFFERENT LEVELS OF RECOVERY:

Minimal *(A minimum level of service is restored, primarily for the use of emergency responders, repair crews, and vehicles transporting food and other critical supplies.)*	
Functional *(Although service is not yet restored to full capacity, it is sufficient to get the economy moving again—e.g. some truck/freight traffic can be accommodated. There may be fewer lanes in use, some weight restrictions, and lower speed limits.)*	
Operational *(Restoration is up to 80-90% of capacity: A full level of service has been restored and is sufficient to allow people to commute to school and to work.)*	
TIME NEEDED FOR RECOVERY TO 80-90% OPERATIONAL GIVEN CURRENT CONDITIONS:	✕

For a number of components, the timeframes marked in the table reflect the estimated recovery period following a worst case scenario earthquake. See the notes following the table for details.

For interstates, state routes, and state bridges, WSDOT anticipates meeting these targets in considerably less time than 50 years.

TARGET STATES OF RECOVERY: WASHINGTON'S TRANSPORTATION SECTOR

	Event occurs	0–24 hours	1–3 days	3–7 days	1 week–1 month	1 month–3 months	3 months–1 year	1 year–3 years	3 + years
Interstate 5									
Puget Sound (center & north end)								✕	
South end (Chehalis south)							✕		
Interstate 90									
Puget Sound (Snoqualmie Pass west)								✕	
Cascades to eastern WA (Snoqualmie to Idaho)							✕		

Interstate 405									
South end (Tukwila to I-90)								✕	
North end (I-90 to Lynnwood)								✕	
Ferry operations							✕		
Floating Bridges									
SR 520								✕	
I-90							✕		
Hood Canal					✕				
25% of major & minor arterials					✕				
50% of major & minor arterials						✕			
75% of major & minor arterials							✕		
90% of major & minor arterials								✕	
Airports								✕	
Airport for emergency traffic					✕				
Ports and navigable waterways								✕	
Rail (freight & passenger)								✕	
Mass transit[3]									
	Event occurs	0–24 hours	1–3 days	3–7 days	1 week–1 month	1 month–3 months	3 months–1 year	1 year–3 years	3 + years

Interstates and Floating Bridges

This component consists of Interstates 5, 90, and 405 and floating bridges SR 520, I-90, and Hood Canal.

Target timeframe for response and recovery: between 1–3 days and 1–3 months, depending on location

Anticipated timeframe based on current capacity: between 3 months–1 year and 1–3 years, depending on location

The actual response and recovery time will depend on a number of factors. For example:

- The number of WSDOT personnel who are able to report to work may be limited by a variety of circumstances, including where personnel were at the time of the earthquake and whether they sustained injuries.

[3] The recovery estimates for mass transit mirror the estimates for major and minor arterials.

- Bridges and roadways in the areas affected by the earthquake must be inspected. How long this takes will depend on the number and accessibility of the structures and the availability of qualified inspectors.
- Some bridges and segments of road may be rendered unusable or only partially usable as a result of the earthquake or secondary effects. The response and recovery timeframe will depend on the number, the location, and the extent of the damage.
- Certain earthquake scenarios could result in damage to the Ballard Locks and cause the water level in Lake Washington to drop below the level required to operate the floating bridges.
- Depending on the scenario and local conditions, liquefaction and slope failure could damage both interstates and planned detours.

During the first three days after the event, the Washington State Department of Transportation (WSDOT) will inspect bridges and begin repairs as needed. WSDOT's first priority will be to open key routes for emergency response vehicles. Subsequent phases of recovery will include setting up detours where necessary and regulating the type and volume of traffic in order to give the public as much access as possible while damaged roads and bridges are repaired.

WSDOT has instituted a program to retrofit existing bridges.[4] Retrofit priorities are based on seismic risk, deficiencies in structural detail, and the importance of the route as a lifeline corridor. The current goal of the bridge retrofit program is to prevent collapse and not necessarily to ensure full operation following an earthquake. The current program does not address any impacts associated with ground movement on existing bridge foundations, roadway sub-grades, or slope stability. WSDOT's approach has been developed based on observed damage to similar systems around the world and cost implications. WSDOT has reported that earthquake damage to bridge structures around the world has primarily been focused on the superstructure-to-substructure connection and columns. From a cost/benefit standpoint, WSDOT has determined that retrofitting for ground movement due to liquefaction or foundation stability is not the best use of the limited available funds. WSDOT does address liquefaction effects on new projects and bridge widening projects, but not as stand-alone remediation work.

Over 45 percent of the bridges listed in the program have been completely or partially retrofitted or are currently under contract for retrofitting. Retrofitting of the remaining bridges will proceed as funds permit.

- I-5: The current focus of retrofitting (which is progressing from south to north) is the corridor between Joint Base Lewis-McChord and the I-5 and I-90 Interchange in Seattle. I-5 should be fully hardened within the next 10 years. WSDOT is evaluating the benefits of retrofitting one direction on sections of I-5 with long viaducts in the initial stage. This

[4] See http://www.wsdot.wa.gov/Bridge/Reporting/SeismicRetrofitProgram.htm

approach will expedite the pace at which segments of the lifeline routes can be retrofitted to carry at least limited bi-directional traffic.

- I-90: All but six retrofits have been completed up to Snoqualmie Pass, making this a feasible route for transporting emergency personnel, supplies, and equipment from Grant County International Airport (Moses Lake) to sites in western Washington.

RECOMMENDATIONS

- Undertake a more thorough statewide investigation and assessment of the liquefaction hazard and its potential effects, focusing particularly on the highest acceleration zones.
- Provide WSDOT with more direction regarding the routes that should be hardened to provide the best access into and out of the Kent Valley.

Ferry Operations

This component consists of the fleet of 22 ferries and 20 terminals that the Washington State Department of Transportation operates in Puget Sound for the use of commuters, tourists, and commercial vehicles.

Target timeframe for response and recovery: between 0–24 hours and 1week–1 month

Anticipated timeframe based on current capacity: 3 months–1 year

The actual response and recovery time will depend on a number of factors, including:

- The status of upgrades and retrofitting of key facilities and equipment.
- The number of terminals that are damaged by the earthquake or secondary effects (such as liquefaction, landslides, and flooding) and the extent of that damage.

Because ferry terminals are located next to the water, their facilities are often constructed on soils that are prone to liquefaction. Their location also makes them vulnerable to flooding from tsunamis and seiches.

Following an earthquake in the Puget Sound region, the ferry system will experience an increase in the number of users while the road systems are being repaired. The ferry system has a good emergency response and recovery plan and is prepared to perform a role after the earthquake that the ferries do not perform now.

After an earthquake, ferries will operate initially in pedestrian-only mode.

WSDOT is also creating traffic models to address the off-loading of vehicles and corresponding increase in traffic around terminals when ferries dock. This analysis may provide useful information for both WSDOT and local planners.

RECOMMENDATIONS

Solicit input from port administrators to identify which transportation routes are most crucial to port operations so that WSDOT and local transportation planners can prioritize these routes for seismic retrofitting

Major and Minor Arterials

This component encompasses arterial roadways (including bridges) other than the interstates. It therefore includes state highways and many city and county roads.

Target timeframe for response and recovery: between 0–24 hours and 3 months–1 year, depending on location; the percentage of roadways that are open for use will increase over this period.

Anticipated timeframe based on current capacity: between 1 week–1 month and 1–3 years, depending on location; the percentage of roadways that are open for use will increase over this period.

The actual response and recovery time will depend on a number of factors, including:

- The amount of time it takes to inspect bridges and roadways in the areas affected by the earthquake.
- The number of bridges and segments of road that are rendered unusable or only partially usable as a result of the earthquake or secondary effects.
- The extent to which liquefaction and slope failure cause damage to both roadways and planned detours.

RECOMMENDATIONS

- Develop interagency agreements between WSDOT and local jurisdictions to facilitate the rerouting of traffic (as needed) following an earthquake.
- Encourage counties and cities to work together to identify lifeline corridors and prioritize and retrofit bridges to serve the greatest need. Include mass transit agencies, school districts, postal services, businesses, and other agencies that rely on these roadways in these discussions.
    - Investigate what is being done by cities and counties to identify alternate routes.
    - Tie both primary and secondary arterials to transit, snow, and evacuation routes to help communities identify their lifelines.

Airports

Target timeframe for response and recovery: between 0–24 hours and 1week–1 month

Anticipated timeframe based on current capacity: 3 months–1 year

The actual response and recovery time will depend on a number of factors. For example:

- Depending on the earthquake scenario and soil conditions, liquefaction may affect the usability of some runways.
- If upgrades and retrofitting of key facilities and equipment has not been completed before the earthquake, these structures are likely to sustain greater damage.
- Extensive damage to fuel lines and other essential utilities may substantially slow the recovery.
- The number of airport personnel who are able to report to work may be limited by a variety of circumstances, including where personnel were at the time of the earthquake and whether they are able to travel to and from work following the earthquake.

On the whole, airports are built on good ground, and WSDOT's lifeline corridor does include connectivity to airports. WSDOT:

- Has retrofitted SR 518 to SeaTac Airport.
- Is retrofitting I-5 to Joint Base Lewis-McCord.
- Will retrofit SR 525 to Paine Field.

WSDOT is also working on I-5 by King County Airport.

If fuel lines are damaged, jet fuel can be transported in by air until repairs are completed.

RECOMMENDATIONS

- Standardize post-disaster damage assessment and reporting.
- Assess whether routes to and from airports are sufficiently hardened; retrofit these routes if needed.

Ports and Navigable Waterways

This component consists of Washington' system of ports and shipping routes, including piers, wharves, seawalls, container storage yards, marinas, and other facilities and equipment on which the operations of the ports depend.

Target timeframe for response and recovery: between 3–7 days and 1–3 months

Anticipated timeframe based on current capacity: 1–3 years

The actual response and recovery time will depend on a number of factors, including:

- The extent of damage caused by the earthquake, particularly such secondary effects as liquefaction, landslides, and flooding.
- The status of upgrades and retrofitting of key facilities and equipment.

Because ports are built alongside the water, their facilities are often constructed on soils that are prone to liquefaction. Their location also makes them vulnerable to flooding from tsunamis and seiches.

The vulnerability of ports is of particular concern because of the serious short- and long-term economic impacts that the state will experience if ports are slow to recover from an earthquake. In particular, ports that do not recover quickly will permanently lose a significant part of their customer base to other competing ports located outside of the region.

RECOMMENDATIONS

- Compel ports to step up efforts to assess the seismic vulnerability of their facilities and equipment.
- Compel ports to retrofit existing port facilities to improve their capacity to recover quickly from earthquakes and secondary effects.
- Ensure that ports have backup facilities for the critical aspects of port administration. Backup facilities should be located in areas outside the zones likely to be damaged by earthquakes.
- Solicit input from port administrators to identify which transportation routes are most crucial to port operations so that WSDOT can prioritize these routes for seismic retrofitting.

Rail

This component includes both passenger rail services and the freight services provided by numerous privately owned railroad companies, along with the tracks, bridges, overpasses, signal systems, and other facilities and equipment on which they depend.

Target timeframe for response and recovery: between 3–7 days and 1–3 months

Anticipated timeframe based on current capacity: 1–3 years

The actual response and recovery time will depend on a number of factors, including:

- The number and extent of earthquake-induced landslides that block and damage rail lines.

The primary objective following an earthquake will be the restoration of freight traffic. Landslides are the key concern. (WSDOT is using federal funds to mitigate this for light rail.) In general freight services will resume immediately after a landslide is cleared, but passenger services will wait 24 hours.

RECOMMENDATIONS

Determine whether the rail companies have considered the possible effects of liquefaction when assessing the vulnerability of rail lines and bridges.

Mass Transit

This component includes all public transportation systems other than the ferry system.[5] Because these systems—and public buses in particular—depend on the functionality of roadways and bridges, the recovery of mass transit will depend predominately on the recovery of the network of major and minor arterials along which mass transit routes run.

Target timeframe for response and recovery: between 0–24 hours and 3 months–1 year, depending on location; the percentage of roadways that are open for use will increase over this period.

Anticipated timeframe based on current capacity: between 1 week–1 month and 1–3 years, depending on location; the percentage of roadways that are open for use will increase over this period.

The actual response and recovery time will depend on a number of factors. For example:

- Bridges and roadways in the areas affected by the earthquake must be inspected. How long this takes will depend on the number and accessibility of the structures and the availability of qualified inspectors.
- Some bridges and segments of road may be rendered unusable or only partially usable as a result of the earthquake or secondary effects. The response and recovery timeframe will depend on the number, the location, and the extent of the damage.
- Depending on the scenario and local conditions, liquefaction and slope failure could damage both interstates and planned detours.
- Fuel may be unavailable or available only in limited quantities following the earthquake.
- Some transit facilities may incur damage as a result of the earthquake or secondary effects.

[5] While light rail is part of the Mass Transit system, for the purposes of this initiative, it is also addressed as part of the *Rail* component.

- The speed with which repairs are made will depend on a number of factors, including the availability of spare parts.
- The number of transit employees who are able to report to work may be limited by a variety of circumstances, including where personnel were at the time of the earthquake and whether they are able to travel to and from work following the earthquake.

RECOMMENDATIONS

- Identify, review, and update interagency agreements between WSDOT and local jurisdictions to facilitate the rerouting of traffic (as needed) following an earthquake. Develop such agreements where they do not currently exist. Review interagency agreements annually.
- Encourage counties and cities to work together to prioritize and retrofit bridges to serve the greatest need. Include mass transit agencies in these discussions.
- Encourage transit companies to assess the earthquake vulnerabilities of their facilities and to gather information about recommended facility updates designed to minimize damage in the event of an earthquake.
- Incorporate earthquake scenarios into regular company emergency planning drills.
- Identify, review, and update the continuity of operations plans of all transit agencies (large and small). Develop such plans where they do not currently exist. Review continuity of operations plans annually.

General Recommendations

- As part of pre-earthquake planning, identify the people who will need to participate in the decision making process by means of which alternate routes will be selected after an earthquake occurs.
- Develop a means of educating the public about how to get around in the event of an earthquake/disaster.

Housing and Economic Development

The following table provides a summary of the estimated timeframes for recovery of key components of the infrastructure, systems, and services of the Housing and Economic Development sector in the state of Washington. The Xs indicate the sector group's best educated guess regarding the current timeframe for the response and recovery of each component and subcomponent after a scenario earthquake. The colored areas represent the goals or targets for each component and subcomponent. (These targets indicate the recovery timeframes that are necessary to achieve resilience in the state of Washington.) The gaps between the Xs and the shaded areas reveal the need for further evaluation, policies, and actions to improve Washington's resilience.

KEY TO THE TABLE

TARGETS TO ACHIEVE DIFFERENT LEVELS OF RECOVERY:

Minimal	
Functional:	
Operational (time it ought to take to restore component to 80-90% operational):*	
TIME NEEDED FOR RECOVERY TO 80-90% OPERATIONAL GIVEN CURRENT CONDITIONS:	✖

For a number of components, the timeframes marked in the table reflect the estimated recovery period following a worst case scenario earthquake. See the notes following the table for details.

TERMS USED IN THE TABLE

- **Occupiable:** The housing unit is structurally sound, safe, and sanitary (sewer and water are available within the dwelling unit or in close proximity), and people can use it to shelter in place following the earthquake.
- **Mid-rise structures:** 4 to 10 stories
- **High-rise structures:** Higher than 10 stories

TARGET STATES OF RECOVERY: WASHINGTON'S HOUSING & ECONOMIC DEVELOPMENT SECTOR									
	Event occurs	0–24 hours	1–3 days	3–7 days	1 week–1 month	1 month–3 months	3 months–1 year	1 year–3 years	3 + years
Finance and banking					✕				
Commerce (commercial facilities)						✕			
Real estate and construction					✕				
Manufacturing (industrial facilities)						✕			
Planning and community development						✕			
Unreinforced masonry structures									✕
Housing									
Detached single-family residential (pre-1950)							✕		
Detached single-family residential (post 1950)					✕				
Mid- and high-rise structures (pre-1977)								✕	
Mid- and high-rise structures (post 1977)						✕			

Finance and Banking

The finance and banking component includes local branches of banks, ATM machines, and insurance providers.

Target timeframe for response and recovery:

- *Minimum level: within 1–3 days, at least 50% of services will be restored.*
- *Functional level: within 3–7 days, at least 75% of services will be restored.*
- *Operational level: within 1 week–1 month, at least 90% of services will be restored.*

Anticipated timeframe based on current capacity: 3–7 days

The actual response and recovery time will depend on a number of factors. For example:

- If the communications network is damaged or overwhelmed by users, it may be unable to support electronic transactions and communication between banks and branches.
- Damage to roads, bridges, and other transportation infrastructure may prevent vehicles from bringing cash and generators into areas damaged by the earthquake or secondary effects. The availability of vehicles may also be limited.

- The overall speed of this component's recovery depends significantly on the speed with which electricity is restored, particularly to ATMs.
- The timeframe required to bring in building inspectors to determine whether buildings are usable and to assess the need for repairs or new construction will vary depending on the scenario and local conditions.

This component's initial priorities for recovery will include making cash available to the population, providing emergency loans, processing deposits, and, in the case of insurance, sending personnel in to assess damage and distribute money.

RECOMMENDATIONS

Develop a means of coordinating the response and recovery efforts of the finance and banking component with the public emergency response. In particular, a clear connection needs to be established between the public emergency response hub and this component's emergency response representatives. The existing forums for coordination within the finance and banking component are CPARM, PNWER, and Washington First, with Washington First having served in the past as the primary contact for emergency response information.

Commerce (Commercial Facilities)

This component consists of retail businesses (local stores as well as regional and national chains).

Target timeframe for response and recovery:

- *Minimum level: during the first 1–3 days, retailers will begin to gain access to facilities and will focus on cleaning up and assessing inventory.*
- *Functional level: within 3–7 days, utilities will be restored, just-in-time inventories will begin to be restocked, and stores will have some ability to provide merchandise to customers.*
- *Operational level: within 1 week–1 month, stores will be able to restock and sell merchandise with few limitations.*

Anticipated timeframe based on current capacity: 1 month–3 months

The actual response and recovery time will depend on a number of factors. For example:

- The state of the transportation infrastructure, including service roads, will determine the ability of businesses to transport goods and restock just-in-time inventories.
- Retailers are dependent upon the speed of the overall economic recovery: in particular, the ability and willingness of consumers—many of whom may have temporarily or permanently left the affected area—to make purchases.

- Commercial buildings that were not designed to withstand an earthquake and that have not been seismically retrofitted are more likely to sustain serious damage during an earthquake. The length of the recovery period will depend on the extent of the damage and the number of buildings affected.
- If the communications and internet systems are damaged or overwhelmed by users, they may be unable to support the processing of transactions.

RECOMMENDATIONS

- Mandate a process of inspection for commercial structures to determine whether structural and nonstructural retrofitting has been done. Such a review and checklist would be done by the seller/owner when the building is to be sold or refinanced.
- Develop legislation that determines who will be permitted to initiate repairs so as to keep local resources engaged; develop small-works rosters of local trades-people.
- Develop a plan for dealing with point-of-sale issues without electricity.
- Ask the state legislature to consider how funds might be used to keep local jurisdictions from going bankrupt when, following an earthquake, sales tax decreases at all levels.
- For small businesses:
    - Emphasize the importance of continuity planning.
    - Explore the possibility of mentoring between big and small businesses.
    - Offer incentives (e.g. low interest loans and government subsidies; for example, if a business does a certain number of things to become more resilient, have the state offer reductions of the B&O tax and insurance premium).
    - Fund plans through a reduction in B&O tax.
    - Strengthen & promote mutual aid.
    - Encourage businesses to have remote data backup.
- Review IBC and GMA codes (in connection with commercial facilities) to promote incentive-based retrofitting when possible.

Real Estate and Construction

This component includes construction companies, contractors, and real estate agencies.

Target timeframe for response and recovery:

- *Minimum level: 1–3 days*
- *Functional level: 3–7 days*
- *Operational level: 1 week–1 month*

Anticipated timeframe based on current capacity: 3–7 days

The actual response and recovery time will depend on a number of factors. For example:

- The ability of building owners to get into damaged areas in order to make assessments will be determined by the state of the transportation infrastructure and the speed with which access is restored.
- Damaged structures must be assessed by qualified inspectors, whose numbers and availability may be limited.
- The time required for the local building and planning departments to issue permits will depend on such factors as the availability of personnel and the size of the area affected by the earthquake.
- Debris will have to be removed and disposed of. The length of time this takes will depend on a number of factors, including the size of the area affected, the quantity of the debris, and the state of the transportation system.
- The availability of building materials, tools, and equipment may be limited, particularly if the demand is great.

RECOMMENDATIONS

Facilitate mutual-aid agreements and adopt licensing regulations (where these are lacking) that will (1) enhance the abilities of local planning departments to bring in building officials from elsewhere to supplement those in the disaster area and (2) allow businesses to bring in security providers from out of state if necessary.

Manufacturing (Industrial Facilities)

This component includes manufacturers such as Boeing and the buildings and equipment on which they rely.

Target timeframe for response and recovery:

- *Minimum level: 3–7 days*
- *Functional level: 1 week–1 month*
- *Operational level: 1–3 months*

Anticipated timeframe based on current capacity: 1 week–1 month

The actual response and recovery time will depend on a number of factors, including:

- The state of the transportation infrastructure (including rail) and its ability to support the supply system and deliver inventory.
- Whether manufacturing structures in vulnerable areas have been seismically retrofitted.
- The extent of damage to manufacturing instruments, equipment, and other non-structural elements.

RECOMMENDATIONS

Identify vulnerabilities in the supply chains of manufacturing industries; bring manufacturers together to find alternative suppliers (etc.) to ensure continuity during disasters.

Planning and Community Development

This component includes building codes, permitting processes, and the capacity of local governments and state agencies to review plans and issue permits for demolition, repairs, and new construction.

Target timeframe for response and recovery:

- *Minimum level: 3–7 days*
- *Functional level: 1 week–1 month*
- *Operational level: 1 month–3 months*

Anticipated timeframe based on current capacity: 1 month–3 months

The actual response and recovery time will depend on a number of factors. For example:

- The availability of planning and development staff and their ability to report to work may be limited by a variety of circumstances, including where personnel were at the time of the earthquake and whether they are able to travel to and from work following the earthquake.
- Buildings that house the permitting agencies could be significantly damaged by the earthquake or secondary effects.
- Depending on circumstances, permitting agencies may seek to contract with and bring in additional staff to carry out assessments and permitting.
- The amount of time it takes to carry out demolition and debris removal will depend on factors such as the size of the area affected, the quantity of the debris, the availability of equipment, and the state of the transportation system.
- The ability of building inspectors to get into damaged areas in order to carry out inspections will be determined by the state of the transportation infrastructure and the speed with which access is restored.
- The existence (prior to the earthquake) of well developed planning and visioning documents that lay the ground work for recovery could help accelerate the recovery of this component.

During the initial phase of recovery, the focus of this component will be on mobilizing qualified inspectors and addressing emergency repairs. To expedite permitting, personnel from other parts of the permitting agency may be reallocated. Also, additional building and permitting officials from other regions may be brought in to help.

RECOMMENDATIONS

- Encourage building departments to become more engaged with the mitigation efforts of emergency managers.
- Give consideration to *revisioning* both prior to a disaster (e.g. mitigation policies related to post-disaster reuse of land) and after a disaster (e.g. rethink fundamental development, engineering, and design).
- Develop further means of expediting the process of reviewing and granting permits for construction and reconstruction following an earthquake.
- Strengthen building codes, especially for hospitals and for mid- and high-occupancy facilities.
- Develop incentives for starting the market for base-isolated, higher performance structures.

Unreinforced Masonry Structures (URMs)

Target timeframe for response and recovery: 3 months–1 year (for 80% of URMs to be occupiable)

Anticipated timeframe based on current capacity: 3+ years

The actual response and recovery time will depend on a number of factors, including:

- The number of structures that were seismically retrofitted prior to the earthquake.
- The amount of time it takes to restore the utilities (sewer, water, electricity) to structures that are otherwise undamaged or only minimally damaged.
- The availability of contractors and building materials.

Unreinforced masonry structures are highly vulnerable to ground shaking and (depending on the location and scenario) are likely to experience severe damage during an earthquake.

Many buildings that are considered historically significant or serve as community focal points are constructed of unreinforced masonry and are therefore at significant risk. Also, public buildings (such as city halls and courthouses) in many towns and small cities fit into this category of building, which also includes a large number of commercial buildings (such as brick warehouses) and older residential structures. Unreinforced masonry structures can be very expensive to retrofit. Depending on the building, historic preservation issues may also complicate retrofitting and other available mitigation options.

RECOMMENDATIONS

- Work with preservation societies to develop plans for retrofitting buildings of historical significance.
- Prepare a more detailed inventory of the actual building stock (types of buildings, dates of construction, and seismic retrofits) in all jurisdictions across the state.
- Work with the Department of Commerce to develop a model code or guidance regarding the various options that exist (e.g. tax breaks) that would encourage owners to retrofit, at least to improve life safety.
- Implement an ordinance to limit the use of such structures—for example, prohibit their use as preschools, senior centers, and child care facilities.
- As an incentive for retrofitting, have the state offer to sign a long-term lease if the owners of the buildings used by the state will invest in retrofitting. Establish a minimum level of resilience and develop a list of options (vetted by qualified engineers) for achieving it.

Housing

The estimates for this component take into account all residential structures except those constructed of unreinforced masonry (URMs). URMs are addressed separately (see above).

The estimates for residential buildings differ according to type and date of construction, but in general, the response and recovery timeframes of this component will depend on such factors as:

- The number of structures that were built recently (and therefore to a higher earthquake standard) or were seismically retrofitted prior to the earthquake.
- The availability of qualified inspectors to determine whether structures are fit for occupation following the earthquake.
- The state of the transportation infrastructure and the amount of time it takes to clear access routes into neighborhoods damaged by the earthquake.
- The amount of time it takes to restore the utilities (sewer, water, electricity) to homes.
- The amount of time it takes to process and issue building permits for repairs.
- The availability of contractors and building materials.
- The amount of time it takes to process insurance payouts.[6]

DETACHED SINGLE-FAMILY RESIDENTIAL (PRE-1950)

Target timeframe for response and recovery:

- *Functional level: 75% of homes occupiable within 1–3 days*
- *Operational level: 90% occupiable within 3–7 days*

Anticipated timeframe based on current capacity: 3 months–1 year

[6] In Washington, only about 14% of homeowners have insurance coverage for earthquakes.

DETACHED SINGLE-FAMILY RESIDENTIAL (POST 1950)

Target timeframe for response and recovery:

- *Functional level: 75% of homes occupiable within 0–24 hours*
- *Operational level: 90 % occupiable within 1–3 days*

Anticipated timeframe based on current capacity: 1 week–1 month

MID- AND HIGH-RISE STRUCTURES (PRE-1977)

Target timeframe for response and recovery:

- *Functional level: 50% of structures occupiable within 3–7 days*
- *Operational level: 90% occupiable within 1–3 months*

Anticipated timeframe based on current capacity: 1 year–3 years

This category of housing includes both apartment buildings and condominiums. The performance and recovery of such structures is of particular concern: If it takes longer than three months to restore people to their homes, many people are likely to relocate all together. This would have a detrimental effect on the economy and would slow the recovery of the community as a whole.

MID- AND HIGH-RISE STRUCTURES (POST 1977)

Target timeframe for response and recovery:

- *Functional level: 75% of structures occupiable within 1–3 days*
- *Operational level: 90% occupiable within 1 week–1month*

Anticipated timeframe based on current capacity: 1 month–3 months

The actual response and recovery time will also depend on factors such as:

- The extent of structural damage, such as damage to egress or, in the case of steel structures, damage to connections.
- The availability of qualified engineers and contractors and the speed with which permits can be granted.
- Fabrication time for steel structures.

The seismic standards in the building code were significantly strengthened in the mid-1970s. As a result of subsequent evaluations of how buildings performed in actual earthquakes and given additional changes to the code during the 1990s, buildings that were constructed during the 1990s and later are likely to perform better than many structures built in the 1970s and 1980s.

RECOMMENDATIONS FOR HOUSING

- Prepare a more detailed inventory of the actual building stock (types of buildings, dates of construction, and seismic retrofits) in all jurisdictions across the state.
- Build new structures to a higher seismic standard.
- Develop and implement a public education campaign to inform home/building owners of the incentives for retrofitting and show them how investing in mitigation and risk management will save money in the long run.
- Develop a simple checklist and disclosure statement to be completed by the seller/owner of a building when the building is to be sold or refinanced. Such a statement would inform the prospective buyer, mortgage holder, and insurer about whether seismic retrofitting or other mitigation has been done (for example, whether the house is or is not bolted to the foundation).
- Encourage insurance companies to offer a lower rate to building/home owners who certify that they have retrofitted for earthquakes.
- Create a task force to look at insurance models in other countries (e.g. Chile and New Zealand) and develop a model that would work in this state.
- Develop a loan program that would allow building/home owners to borrow money for the purpose of retrofitting (such loans to be offered by banks, but with state or federal backing).
- Offer a decrease in state property tax as an incentive for investment in seismic retrofitting.
- Institute a small (1 cent) dedicated sales tax in support of seismic mitigation policies and projects.
- As part of job training programs associated with the construction field, train people to do retrofitting at minimal cost. (This could involve a partnership with technical colleges, community colleges, or some of the trades in order to offer the job training at low or no cost).
- Develop a prescreening program similar to San Francisco's Building Occupancy Resumption Program (BORP), which allows building owners to pre-certify private post-earthquake inspection of their buildings. (Provided the structure does not exceed a certain level of shaking, the building will automatically have a green tag without the full post-earthquake inspection.)
- Use NetQuakes seismographs (small seismometers that are tied into the seismic network) to provide data to engineers and inspectors to help in the tagging process.
- Invest in the further development of RF identification tags that can be installed in buildings and that will activate during an earthquake and monitor acceleration, displacement, and so on. (Such tags would help speed up assessment and make it more accurate.)

General Recommendations

Develop a centralized way (for use in disasters) to locate housing, commercial facilities, and manufacturing facilities.

Summary of Interdependencies

As they identified the recovery timeframes of the various components of Washington's systems and infrastructure, the four sector groups and the participants in the workshops also discussed the degree to which the recovery of one component or sector would depend on the restoration of another. The key interdependencies that the participants identified include the following:

Information and Communication Technologies: The resilience of this component and the speed with which it recovers are critical to the effectiveness and speed of the emergency response following an earthquake. In particular, emergency operations centers, first responders, and repair crews all rely on these technologies to coordinate their response. This component will also affect the recovery of finance and banking, commerce, and government administration, which rely on this component to facilitate transactions and transfer information.

Transportation: The successful response and recovery of the majority of components depend on their ability to move people (including emergency responders, repair crews, and inspectors), equipment, food and supplies, fuel, and other essential materials into the areas impacted by the earthquake. The transportation system is likewise necessary for removing debris.

Electricity: The successful response and recovery of the majority of components depend substantially on the swift restoration of electricity. Even critical facilities can rely on backup power supplies only for short periods and cannot sustain normal functions until the primary power is restored.

Fuel: Fuel is needed to power backup generators and to run the vehicles that transport emergency responders, inspectors, repair crews, parts, and equipment. Fuel is also needed for aircraft, ferries, and transit busses, and to maintain the operations of many industries.

Domestic Water Supply: Effective fire suppression after the earthquake will depend on the functionality of the domestic water system. A functioning water supply is also essential at critical facilities such as hospitals. The restoration of residential neighborhoods, commercial business, and industrial facilities will likewise depend on the swift recovery of this component.

Wastewater Systems: The restoration of the wastewater system is as essential as the restoration of the domestic water supply. Widespread damage to these systems may also impact the overall health of the population.

Finance and Banking: For most components, the ability to carry out financial transactions is essential both during the initial response and as a key part of restoring normal operations.

Planning and Community Development: The recovery of the majority of components is tied to the speed with which buildings are inspected and permits granted for building and repair.

Appendix A: Venue & Agenda

Details of final RWS Workshop on December 2, 2011:

VENUE

Henry M. Jackson Federal Building, 4th floor auditorium
915 Second Avenue
Seattle, WA 98174

AGENDA

8:30–9:00 a.m.	*Check-in and Coffee Reception* ★
9:00–9:15	Welcome & Introduction (Dave Norman and Jim Mullen)
9:15–9:30	Recap: Resilient Washington State Process and Goals (Stacy Bartoletti)
9:30–10:30	Sector Group Presentations (Critical Services; Housing & Economic Development)
10:30–10:45	*Break*
10:45–11:45	Sector Group Presentations (Transportation; Utilities)
11:45–12:00	Introduction of Breakout Groups (Stacy Bartoletti)
11:45–2:00	Working Lunch★: Breakout Groups (sector group leaders)
2:00–2:15	*Break*
2:15–3:40	Breakout Group Reports and Discussion (Stacy Bartoletti)
3:40–4:00	Wrap Up

★Coffee Reception sponsored by Degenkolb
Lunch sponsored by CREW

Appendix B: Participants

	Last Name	First Name	Organization/Affiliation
1	Anderson	Mark	Department of Commerce
2	Ash	Cale	Degenkolb Engineers
3	Ballantyne	Don	Degenkolb Engineers
4	Bartoletti	Stacy	Degenkolb Engineers
5	Biasco	Tamra	FEMA RX
6	Bower	Dick	City of Gig Harbor
7	Davis	Charles	Washington Federal
8	Eichhorn	Lawrence	Seattle Department of Transportation (EM)
9	Freitag	Bob	University of Washington
10	Gonzalez	David	Degenkolb Engineers
11	Graff	Barbara	Seattle Office of Financial Management
12	Green	Rebekah	Western Washington University, Resilience Institute
13	Hildreth	Richard	Mayor, City of Pacific
14	Himmel	John	Washington State Department of Transportation
15	Holdeman	Eric	Port of Tacoma
16	Hutchinson	Jim	Washington State Emergency Management Division
17	Huxford	CJ	Western Washington University
18	Jensen	Grant	Williams Pipeline Co.
19	Labadie	John	Consultant, Emergency Management
20	Lokey	Bill	Witt Associates
21	Loveless	Randy	Reid Middleton
22	Lund	Erika	City of Seattle, Emergency Management
23	Lundeen	Terry	Coughlin Porter Lundeen, Inc.
24	Maykovich	Vince	FEMA Region X, Planning Section Chief
25	Miles	Scott	Western Washington University, Resilience Institute
26	Mitra	Anindita	CREA Affiliates
27	Mociulski	Michael	Seattle Public Utilities
28	Mooney	Jamie	Washington State Emergency Management Division
29	Morin	Pat	Washington State Department of Transportation

30	Mullen	Jim	Washington State Emergency Management Division
31	Nelson	Dave	Washington State Emergency Management Division
32	Norman	Dave	WA State Department of Natural Resources, Geology
33	Northey	Lise	Regional Catastrophic Preparedness
34	Nourse	Kyra	Writer & Editor for Resilient Washington State initiative
35	Pierepiekarz	Mark	MRP Engineering
36	Ripley	Sam	City of Pacific, VISTA volunteer
37	Roberts	Shawn	Washington State Department of Health
38	Schelling	John	Washington State Emergency Management Division
39	Scofield	Joan	WA Office of Insurance Commission
40	Subsits	Joe	WA Utilities & Transportation Commission
41	Ufford	John	Washington State Emergency Management Division
42	Walsh	Tim	WA State Department of Natural Resources, Geology
43	Wesolowski	Mark	Puget Sound Energy
44	West	Don	Golder Associates (for Williams Pipeline Co.)
45	Winecoff	Steven	Community Transit, Everett WA